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RAILWAY TRAIN LIGHTING.

THE paper recently read by Mr. Langdon, the Electrical Superintendent of the Midland Railway, before the Institution of Civil Engineers, ought to have, if it has not, brought home to both manufacturers and railway companies the fact that electricity is destined to fulfil a very important part in railway economy at no distant date. It is now some few years since Mr. Houghton, in conjunction with the late Mr. Stroudley of the Brighton Railway Company, started lighting a Pullman car by means of accumulators, followed very speedily by complete trains, lighted by the agency of a dynamo driven from the axle of one of the vehicles, aided by accumulators arranged in the same vehicle. But in all cases these trains, of which there are now several in operation, are run as a whole—that is, they are not broken up. The Great Northern have also fitted some few metropolitan trains in a similar manner. Some two years or more ago the Midland took the question in hand—not merely, as it appears, with the object of a little sensational lighting, but with the desire to test the application of electricity to the purpose under all the varying conditions to which railway vehicles have to submit—in fact, to ascertain if it could be made to meet every requirement of the traffic; and great credit is due to the Midland Railway directors for the manner in which they have dealt with the subject. Clearly they realised that to be thoroughly useful it was necessary that the system should be shown to be applicable to all the requirements of the service. Trains must be broken up, vehicles must be sent on their branch journeys independent of the generating machine, and, if necessary, whole trains must be capable of being run without the aid of the dynamo. All this has been accomplished, and, apparently, with great general satisfaction, and the Midland have now several trains lighted by electricity running between London, Manchester and Liverpool, between London, Nottingham, Sheffield, Leeds and Bradford, and between London and Bedford, together with one or more local trains. All the main line trains are broken up on the journey, and in some instances parts of the trains are sent over portions of the route dependent entirely for their light upon the current stored up in the batteries which each of the vehicles carry. Mr. Langdon, in his paper, recognised, in the most kindly manner, as will all who have followed the progress of this important question, the services of Messrs. Houghton and Stroudley, whom he regarded as the pioneers of the work; but we cannot ignore the fact that to the Midland Railway Company we owe—we will not say the final stroke—but the greatest stride of all; for it is by the Midland trials, and the experience gained by the Midland, that it has been shown that electricity is capable, not merely of lighting our trains, but of lighting them so as to meet every requirement of the traffic. It is from the Midland that we have the greatest and most complete proof of this. Taking the subject in hand, first with local trains, then with trains broken up on the journey, and finally with the dynamo driven by an auxiliary engine placed on the locomotive, the subject has been carried through what appears to be the entire field. Improvements will no doubt follow, but it would seem that the researches authorised by the Midland board, and so successfully carried out by their electrical staff, have been extended to all channels from which it is probable the electrical power may be obtained.

If then that which has been done has proved the application of electricity to be a reliable and readily workable source of light for the purpose, it would appear that the only questions remaining for determination are its cost, and the agency from which the motive power shall be derived. Mr. Langdon stated in his paper that two locomotives had been fitted with small rotary engines, a "Newall" and a "Brotherhood," and were working trains between London and Bedford; but we did not gather from what was said that they had been in use very long. We cannot, however, avoid thinking that for many reasons the locomotive is the proper thing. In the discussion, as also in the paper, Mr. Langdon himself seemed to indicate this as his opinion. Much success has been obtained by driving from the axle, but although undoubtedly this success is sufficient to encourage progress in this direction, greater efficiency, and truer and more reliable results will be achieved by driving from a

source which is more under control than the wheel of a train which is bound to travel as the locomotive drags it, at one moment at a speed of perhaps 70 miles, at another, at a speed of 30 miles. Moreover, there will always be the difficulty of fast and slow trains, trains stopping at every station and trains not stopping for fifty or a hundred miles. With the locomotive as the seat of power for the electric light, the current may be turned on whenever the locomotive is coupled up to the train; and, whether standing or moving, the batteries may be charging if needed, or the lights be worked direct from the dynamo.

The position for this small installation—a dynamo and engine of about 7 horse-power—appears to be a material question. It would appear that locomotive engineers have very little if any space to spare. In the Midland trials the apparatus has been mounted in an iron box on the top part of the rear of the tender. In the trial made by Mr. Fletcher, of the London and North Western Railway, it is arranged in an iron box behind the tender. But surely there ought to be no difficulty in dealing with this part of the question. If railway companies are satisfied that there is in that which has been, as we think, so ably worked out by the Midland, the germ of a good, reliable, and economical means of lighting their trains, they will surely find space for it. One of the speakers in the discussion explained how an experiment had been made with a small auxiliary engine placed on a locomotive on the Great Eastern Railway, and the cost of working came out at so fabulous a price as to render it evident that his figures, or the means adopted for the trial, were erroneous. According to Mr. Langdon's paper, the cost of working from the axle amounted to about one farthing per lamp of 8 candle-power per hour. Now, whatever may be the cost of working from the axle, the cost of working from an auxiliary engine must be less. This will, we think, be clear to every mind. When the dynamo is driven from the axle, the locomotive has to drive the axle—except, of course, when it is travelling on a falling gradient. There is a certain loss or waste of energy in driving from the axle. There is practically none in driving from the auxiliary engine. It is probable that the power generated by a locomotive varies between five and seven hundred horse-power. The power required for the auxiliary engine would not exceed, as we have said, seven or eight horse-power. What can this effect be upon the whole? Practically *nil!* and such we understood Mr. Langdon to say was the experience of the engine drivers working the trains fitted in this manner.

Of course, it was hardly to be expected that the gas interest would be quite in accord with the Midland Company's experiments. No one would expect Mr. Rickman's views to be in accord with Mr. Langdon's—rather that they would be as diametrically opposite as the poles of the earth—and it was with pleasure we heard Mr. W. H. Preece descant upon what had been done by gas, as represented by Mr. Rickman, and what yet remained. Taking the two—the number of coaches fitted with gas and the number remaining to be fitted by some better illuminant—we do not find that progress suggestive of absolute confidence by the railway companies in gas which Mr. Rickman would have us believe is the case. Is it that Sir Frederick Bramwell in his remarks touched the right chord when he directed attention to the disastrous consequences which must take place if ever an accident should produce an explosion of this highly-compressed gas. Although the Abergeldie accident, to which Sir Frederick referred, was not the result of an explosion of gas, it is quite within the possibilities of railway travelling that the results, where gas is employed, might be equally disastrous. Sir Frederick Bramwell is to be thanked for having thus boldly directed attention to that which is certainly one of the most pernicious properties of this illuminant. We were at first surprised to find it was not referred to in the reading of Mr. Langdon's paper, until we remembered that he was not only the author of the paper but a railway company's officer. This, however, only renders our acknowledgments to Sir Frederick Bramwell the greater.

Reviewing the subject as ventilated by the proceedings of the Institution of Civil Engineers, we are forced to the conclusion that the application of electricity to the lighting of railway passenger trains has been shown to be perfectly feasible and reliable; that in point of cost it very little, if at all, exceeds the cost of gas; that it is by far a more acceptable illuminant than either oil or gas, and will always command the approval of the travelling community. Gas has been in operation for years. Its cost is as low as it probably ever will be; indeed, with the prospect of higher wages, it is probable its cost will increase, but the reverse is the case with electricity; its application in this field is new; increased use will bring reduction in price; patents will fall in, and in all directions less cost will result. No doubt there yet remains a good deal to be overcome, but evidently sufficient has been done to open the way for more. With extended experience we shall have still greater improvement. Drawbacks always attend the introduction of a great improvement such as is embraced by this question, and probably not the least difficult one will be that involving the position which the generating plant shall occupy on the locomotive. Another which may present itself is, that the locomotive service for long journey trains is somewhat disjointed. A locomotive runs but so many miles—say, 50 or 100—when its place has to be taken by another, and so on. Thus, whereas one fitted van serves the entire journey for a train, it may require three or four locomotives; but should an entire service be fitted, then, of course, this is practically immaterial, as in all passenger trains requiring light, each engine would be applied to the purpose as needed.

We readily acknowledge the services rendered by the Brighton Company in the advancement of the electrical industry, and especially those of the Midland, to whom we owe the completion of the experiments commenced by the former company. It is not the first instance in which the Midland Railway Company have placed themselves in the van of improvement. We very heartily congratulate the company, and wish them all the success their efforts deserve. We hope shortly to be able to return to the subject, and, if possible, to publish Mr. Langdon's paper in full. It is our desire to give every possible publicity to that which has in it, we believe, the germs of a great success, and which is destined to play an important part in the economy of railway administration, and to add greatly to the comfort of railway travellers.

THE MULTIPHASE SYSTEM.

IN our article on the Frankfort Electrical Exhibition is a short historical sketch of the development of a system of producing and transmitting electrical energy which has been named the "Drehstrom system" by certain German engineers; the expression, however, was originated by Mr. Dolivo von Dobrowolsky, the engineer of the Allgemeine Elektricitäts Gesellschaft, of Berlin. One of the earliest workers in this field was Mr. F. Haselwander, whose own description, with results of experiments, is embodied in the exhibition article. The system is really a development of the idea of Prof. Ferraris, and it appears that in addition to Mr. Tesla, of American fame, Mr. Haselwander, and Mr. Dobrowolsky, in Germany, and Mr. Wenström, in Sweden, have all, almost simultaneously, been working in the same direction. Comparatively little data is as yet available which would give a general idea of the efficiency of this system, which, for the want of a shorter or more appropiate name we call the multiphase system. Its projectors must, however, have great confidence in it, inasmuch as that gigantic experiment between Lauffen and Frankfort is to be made with Mr. Dobrowolsky's multiphase generators, motors and transformers. The current will be generated at Lauffen, on the river Neckar, by means of a 300 H.P. turbine, driving a multiphase dynamo giving 50 volts, and a current at present unknown. This will be transformed up to 25,000 volts and transmitted by three copper wires of 4 millimetres diameter over a distance of 110 miles.

At Frankfort the current will again be transformed down to 50 volts, and used in motors and for lighting purposes. We shall return, when the opportunity arises, to a full description of this plant, and only give at present a few figures recently published by Mr. Dobrowolsky in the *Electrotechnische Zeitschrift*.

The multiphase motor appears to be an exceedingly simple apparatus, easy to construct, and equally easy to manage. Efficiency tests have been made with a motor of normally 2 H.P., running with 70 volts, at periods of 35 per second. The weight of this machine was 165 kilogrammes, and it was found that it did not get unduly warm when running for long periods at 2 H.P. For a short time it could be loaded to 4 H.P. on the shaft, without very seriously reducing its efficiency. The variation of speed between running empty and with a load of 2 H.P. was only 6 per cent., and by overloading the motor 100 per cent., the speed was still appreciably high, showing its superiority over alternating current motors, which stop altogether when overloaded. When running empty, the motor consumed 205 watts, and the useful mechanical work when applied, increased almost in exact proportion with the electrical energy used, until it reached 3 H.P., when it fell somewhat. A series of tests demonstrated that the efficiency of this motor at half load, or 1 H.P., was 75 per cent.; at its normal load, 2 H.P., 80 per cent., and it reached the maximum, when giving 2·3 H.P., when it was 81·4 per cent. The speeds, unfortunately, are not given. Ignoring the speed for the present, it appears that this multiphase motor compares most favourably with continuous current motors of similar weight.

Another important fact may be noted, and that is that a multiphase motor starts from any position, and exerts a very considerable initial torque. At the moment of starting a resistance is inserted, and this resistance can also be used for varying the speed where it is desirable. Even when overloaded the starting does not occupy more than two or three seconds, and the rotation of the motor can be reversed in about four seconds. From the above statements, it will be seen that for purposes of transmission of power to a distance, this system, since high tension transformers can be used in conjunction with it, will solve the problem which the ordinary alternating current system has not satisfactorily solved. We may assume that the multiphase machines when built on a large scale will have even a greater efficiency than the above-mentioned example, and that the transformers also will return a very large percentage of the energy passing through them; then the three wires will be no objection. And if all our expectations come true, there will be an end to any more installations producing "old fashioned" alternating currents, unless motors can yet be devised to work with them satisfactorily.

AN IMPROVED COPPER STORAGE BATTERY.

READERS of the ELECTRICAL REVIEW will remember the *début*, some six years ago, of the Lalande-Chaperon primary battery and its "valuable" bye-products. Some three years later the Commelin-Desmazures storage battery, based on similar principles, but in a modified and improved form, came before the public. A great deal was promised of this battery, and a deal was expected from it, but we have heard scarcely a word about it since the Paris Exhibition of 1889. Now we are confronted with still further and extensive modifications, which, we hope, will be as great an improvement as the inventors anticipate. Some few weeks ago we were favoured with a confidential communication setting forth several of the virtues of this battery, and since the American press is publishing accounts of it, we feel at liberty to relate what we have been told. The improvements due to Messrs. Entz and Waddell of New York, are certainly worthy of attention. It will be remembered that the Commelin-Desmazures positive plates were made of copper dust compressed, at a very great pressure, to the consistency of a tolerably solid slab, sufficiently porous however, to give a certain storage capacity, It was claimed that this battery had the same efficiency as a lead secondary cell, but independent experiments in London have shown that it lost its charge rapidly when standing idle, and a reasonable efficiency could only be obtained immediately after charging. Moreover, a notable increase in the resistance of the copper plate was observed after a little use. Much trouble was also experienced with the parchment envelope, which was necessary, but which crumbled to pieces by the action of the alkaline solution.

The Waddell-Entz positive plate is built up in the following manner:—a copper wire core is wound spirally with another thin copper wire, and the small spaces between the spirals are filled with powdered copper; this is then put into a wire-covering machine which gives the whole a textile jacket. The resultant material has then the appearance of insulated copper wire, which is bent zig-zag fashion to form

a flat plate. The other electrode is a network of tinned iron capable of taking a zinc deposit. The liquid is said to be potassium zincate. As far as the mechanical construction is concerned it appears that some of the more serious defects of the older forms have been ingeniously overcome. A cell, we are informed, containing eight copper plates, weighing 30 lbs., including box and electrolyte, has a capacity of 700 ampère hours and a potential of ·89 volts on "open" circuit. When discharging at the rate of 100 ampères the E.M.F at the terminals of the cell is ·77 volt. The external dimensions of the cell are 5 inches × 7 inches × 12 inches high. A battery of this construction, consisting of 100 cells, is being tried on a tramcar in Philadelphia; it actuates a Waddell-Entz electric motor which also has some novel features, and to which we shall return in a future issue.

Telephony in France.

WHETHER state undertakings for public service are more admirably conducted than those of a private character is a matter of opinion, but in the case of telephony in France the Government is acting in a very high handed manner. The Director-General of Posts and Telegraphs, M. J. de Selves, addressed on the 21st inst., to the telephone subscribers, a circular letter of which the following is a copy:—"According to the terms of Article 5 of your subscription policy, the various appliances comprising your telephonic apparatus and accessories which you have asked for must be provided by you and at your expense. At the time of the taking over by the State of the Paris network, the Administration left you provisionally in enjoyment of the apparatus which you used. It is to-day necessary to regulate this situation. I beg to inform you that you will have to come to an understanding with the Société Générale des Téléphones for the purchase of your apparatus, and that the latter will shortly forward you its invoice. The company will be legally entitled to remove your instruments within a period not exceeding 14 days, and consequently your connection with the service would be suspended until further order." In referring to this subject, *La Liberté* says: "Can it be true that the State, being unable to arrive at an agreement with the Société Générale des Téléphones for the taking over of its *matériel*, has, in order to get out of the affair, found this ingenious expedient to make the subscribers pay the piper."

Closed Conduit Systems.

IT would be interesting to learn what Mr. Lineff or the Lineff Electric Traction Syndicate thinks of the Pollak-Binswanger closed conduit system of electric traction, which is referred to in another column. The system, before its modification, bore a great resemblance to the Lineff improved closed conduit method, which was not brought forward until nearly four years after the taking out of the patent by Messrs. Pollak and Binswanger. Is this another case of re-invention?

Paper Insulation.

THE Norwich (America) Insulated Wire Company, whose system of insulating wire by paper is stated to be giving very good results, have recently been manufacturing multiple wire telephone cables, the inductive capacity of whose wires is unusually low. It is stated in the *Electrical Review* of New York that No. 18 conductors insulated to ·125, and encased in a lead pipe one-eighth inch thick and two inches outer diameter, which originally gave a capacity of ·22 mf. per mile, are now manufactured to give less than ·085 mf. per mile, a capacity, says our contemporary, which is the lowest ever obtained on a cable of such dimensions either on this or the other side of the Atlantic. This result, if correctly stated, is certainly remarkable, but it is not quite evident whether it is obtained by increasing the thickness of the insulating coat, though the statement is such as to lead one to suppose that it is not. The experience of four years is said to be greatly in favour of the system of insulation, on which we commented some time ago.

Insurance of Electrical Exhibits in Frankfort.

THE machines and instruments at the Frankfort exhibition have been insured against fire and damages from explosion to the extent of 3,500,000 marks, and the risk has been undertaken by 23 of the principal insurance offices. The exhibit of Messrs. Schuckert & Co., alone represents a value of 600,000 marks (£30,000). Messrs. Siemens & Halske have independently insured their exhibits for 761,000 marks, and, in the case of a number of exhibitors, the individual values exceed 100,000 marks. Altogether the property in the Frankfort Exhibition is estimated at seven million marks. These figures give an approximate idea of the magnitude of the undertaking.

Aluminium.

MR. PREECE made a very pertinent remark in his paper on "Some points connected with mains for electric lighting," which we published last week. "It is a pity," said the author, "that some of that redundant mental energy which is endeavouring to raise the efficiency of dynamos and transformers from 94 per cent. to 95 per cent. could not be transferred to the question of mains, where real advancement and true economy, on a considerable scale, are much more required." Now, the desirability of employing aluminium in electrical work is rapidly coming to the front, and we think that a study of the paper by Mr. Alexander S. Brown (see our last issue), may possibly lead to that very transference of redundant mental energy which Mr. Preece so much desires. We are acquainted with at least one well-known electrical engineer who has pinned his faith on the future of aluminium, and there is but little doubt that the subject is one worthy of close attention. But, as Mr. Stetson says, manufacturers must be taught what to do with the material after they get it.

The London-Paris Telephone.

WE understand that an interruption to talking over the London-Paris telephone line took place last week, the fault being on the French side. The mention of this serves as an opportunity for informing our readers that Mr. W. H. Preece will deal exhaustively with this latest phase of long distance telephony at the British Association meeting in August. We believe that much interesting information relative to the working of the line will be elicited.

Air Insulation.

THE use of air as an insulator, was inaugurated, says Mr. Preece, in speaking of electric light mains, by Mr. Crompton, in Kensington. This may possibly be the case, but its employment was discussed at some length in the correspondence columns of the REVIEW, years before the existence of any central station in London.

New Central Station.

TO-MORROW will see the opening of the Central Station, Bulmer Place, Notting Hill Gate, W., belonging to the Notting Hill Electric Lighting Company, Limited.

FACTS AND FIGURES ANENT ELECTRIC TRACTION.

COMPILED BY A. RECKENZAUN.

PROGRESS IN BOSTON.

THE West End Street Railway Company in Boston, Mass., possesses one of the largest, if not the largest, station for generating electric energy. It will contain, when finished, 13 compound steam engines of the Reynolds-Corliss type of 1,000 H.P. each, arranged in two rows of seven and six respectively on the ground floor of the building. The driving pulleys of the engines are 28 feet in diameter, and these transmit the power to long countershafts by means of leather belts, and from thence to the dynamos situated on an upper floor. All the belts are run under tightening pulleys. The dynamos make 400 revolutions per minute, whilst the engines give 40 revolutions per minute. At the end of March last there were 60 miles of tramways in Boston, equipped with 312 electric cars, and the work of extending this system is being pushed ahead as rapidly as possible. Mr. Whitney, the president of the West End Street Railway Company, stated that his station would be ready to supply 13,000 horse-power before next winter.

CABLE *versus* ELECTRICITY.

Discussions between representatives of rival systems of traction are always interesting; they bring before the public statements which are not as a rule to be found in circulars or catalogues. The paper read by Mr. H. M. Kebby before the Engineer's Club of St. Louis, and entitled "Construction and Operation of Cable and Electric Railways," evoked several remarks during a debate which are worthy of reproduction.

Mr. Kebby has for many years been connected with the construction and working of cable tramways, and he naturally looks upon electrical engineers as formidable rivals. One of the principal arguments used by electricians has been that the cost of installation of an electric road was a great deal less than for a cable road, and Mr. Kebby endeavours to show by figures that when comparing the same class of construction the difference is very small. For the purpose of comparison, he takes a road of 10 miles of single tracks and running 30 trains, and he shows that there is a difference of only $3,261 per mile in favour of the electric road. Electricians claim that the cable road is labouring under a disadvantage in having to keep a dead weight moving all the time, namely, the cable, sheaves, and winding machinery. Now, the weight of a ten-mile cable is 132,000 lbs. carried on sheaves with the best lubricated journals that can be devised. The electric roads are carrying motor cars, which, for 30 motors, is 180,000 lbs., and this has not the advantage of being carried on well-lubricated sheaves, but must be rolled along on a more or less dirty rail in the street. As to operating expenses for cable roads, Mr. Kebby is quite positive, whereas figures about the cost of working electric cars were difficult to obtain. For a cable road 10 miles long operating 30 trains, the cost of traction per car mile is 2·44 cents, and this includes power-house expenses, grip repairs and renewals, lubrication of sheaves, renewals of sheaves and every item of expense on road bed and renewal of cable. From indicator diagrams taken all day long in the power-house of a cable road, he found that the power required to move the cables and machinery was 139·9 H.P., and when pulling cars and passengers 287 H.P., which gave 47·6 per cent. of power for cable and machinery. The loss, according to Mr. Kebby, on an electric road, would be from 58 to 70 per cent., and the working expenses, inclusive repairs, 6 cents per car mile.

Mr. E. D. Meier, in opening the discussion, maintained that he had always considered the cable system as unmechanical. To take a moving body weighing some 30 tons, and moving at a regular speed of 8, 10 or even 15 miles an hour, and attempt to attach to it a body weighing two or three tons which is standing entirely at rest, without some means of *gradually* bringing the speed of the latter body up to the speed of the former body is unmechanical, and, in his judgment, bad engineering. The great cost of excavating, yokes, concrete, drainage, &c., will generally make the cable road by far the most expensive construction. He had collected data from a cable line and from two electric lines, which he put into tabulated form for purposes of comparison.

	Cable.	Electric I.	Electric II.
Length of road round trip, miles	9·64	9·00	12·22
Number of days compared	198	198	198
Cost of motive power, including repairs	$29,957.72	$23,664.96	$26,687.88
Total number of train miles	591,703	522,126	980,769
Number of passengers carried...	2,928,918	1,608,532	3,032,425
Actual running time per round trip in minutes ...	64	72	77
Speed in miles per hour ...	9·038	7·5	9·522
Cost of power per train mile in cents	5·06	4·53	2·72
Cost of power per passenger	1·023	1·38	·88
Cost per passenger per mile	·424	·61	·29

In the cable road the train is always composed of two cars, while in electric II., at least for somewhat over one-third of the time each day, the train consists only of the motor car, and electric I. always runs two cars per train, it would not be fair to deduce from that that the cost per car mile, instead of per train mile, would show very much more favourable results for the cable. In the case of the cable road the power required per train varied during the day from 12·86 H.P. to 17·61 H.P. In the electric II., the power at the engines per car hauled varied from 6·87 H.P. to 11·85 H.P. The point which interests the manager of the street railway line, and which must influence the choice of power, is the cost per passenger carried and the cost per passenger mile. This, it will be seen, decreases very rapidly in the case of the electric road, as the number of passengers increases. The reason electric I. shows higher results on these items lies in several conditions. First, the much smaller number of passengers; second, the condition of the streets being much worse than for the other two roads; third, the use of high-speed engines in place of more economical types.

Mr. Winthorp Bartlett said that he did not know of a single instance where the permanent way of an electric road is as substantially and durably built as that of the average cable road. Usually the idea of the railway management is to replace animal power with the least expense, hence the money goes into the steam and electric plants and new cars, while the old permanent way is made to serve. The large increase in mileage of electric roads during the past two years he believes is due to the low first cost, the flexibility, the adaptability to existing lines, and the anticipated economy in operating expenses. There is not so much doubt about the cost of construction as about the cost of operation. To arrive at an equitable comparison of the cost of motive power by cable and electricity, all the items to make up this expense should be included. Mr. Bartlett drew a comparison between Mr. Meier's table and that published about 18 months ago by Mr. O. T. Crosby, referring to traction costs on the electric lines of Washington, Richmond, Cleveland, and Scranton. This table appeared in the ELECTRICAL REVIEW at the time.

Mr. J. S. Seddon took great interest in the data given, as also in the comparison of cable and electric roads. All, he said, will agree to the general proposition, "That each case requires consideration of its special features before deciding for operation by electricity or by cable." The point which he wished to make in the discussion is this: The cable road of which Mr. Kebby has given the data is the result of ten years of the special experience that can only be acquired through the intelligent study of the weak points developed in actual operation; nothing takes the place of working a machine to know its defects; while the electric roads, with which a comparison is invited, have had no such opportunities. The present type is hardly two years old, while there has been so little opportunity of learning the need of, or making improvements, that we may practically class them all as the first construction. He had little doubt that, except in special cases where the gradients, or heavy traffic, necessitates a cable road, the changes in the near

future will be altogether to electric roads. That is, provided overhead wires are allowed.

Mr. J. J. Ayer hit the nail on the head when he stated that the question of comparative merit between cable and electric roads is fully answered by the showing made since their inauguration by the respective systems. During the last 15 years there have been built and successfully operated about 350 miles of cable road at the outside. Within the last two years there have been 2,500 miles of electric roads built and are now in successful operation. That the various street railway companies have been able to change to the electric system by issuing bonds, which have been readily absorbed by capitalists at fair rates of interest and nominal discounts; that so many shrewd men, as the heads of our street railway concerns are conceded to be, have selected the electric system to such a large extent and in such a brief period, are strong arguments in favour of the electric railway. The improvement in the quality of street railway securities, due to the adoption of electricity as a motive power, is well known in all money markets to be very material. Now, if the experience with the crude apparatus which our manufacturers have had to offer has brought about the conditions that now exist, what have we to expect in the near future when the brain and talent of our mechanics and electricians shall be brought to bear to produce an improved quality of apparatus instead of having to work night and day only to partially supply the enormous demand for such apparatus as they have been able to produce after practically only two years' experience? Notwithstanding the considerable expense of maintaining the motors and transmitting machinery as now constructed, the balance sheet must be, in almost every case, quite satisfactory as compared with other methods of propelling street cars. The fact that the first experience with electric apparatus on new roads is always the most expensive, due to the fact that all operators must be educated by the destruction of a certain amount of electrical apparatus at the company's expense before they become proficient and are able to properly care for the same, is a strong argument in its favour.

(To be continued.)

ELECTRICITY IN THE ALPINE COUNTRIES.

[FROM OUR OWN CORRESPONDENT.]

THE utilisation of the masses of water in the Alpine countries, rushing down wildly and uselessly, and their application for the production of light and motive power is at present a main problem for technicists.

In this respect a decided impulse is expected from the Frankfort Electrotechnical Exhibition. As the *Frankfurt Zeitung* announces, there are at present 12 towns in Switzerland on the point of fitting up electric installations for light and power, and numerous capitalists are already securing water power in Switzerland in order to dispense with coal. The imaginative reporter already sees a time approaching when the industrialists of neighbouring countries will obtain their motive power from Switzerland by means of electric transfer of power, and hundreds of waggons of accumulators will daily meet the demand for light and power.

What is hoped in Switzerland applies also to the Austrian Alpine lands, and the Austrian technicists, as Prof. Radinger has recently explained in a description of the mighty installation of turbines at Assling (in the province of Carinthia, in Austria) have gained an advance in the utilisation of vast Alpine water powers. At Assling the falls of the Save, of the height of 25 metres, are utilised in three turbines of each 1,000 H.P., for driving the rolling mills of the Carinthian Iron Company.

The engineer, von Miller, purposes driving the line conceded to him from the baths at Ischl up to the Hutteneck Alpe electrically by means of the mountain streams, and supplying, in addition, the villages Ischl, Laufen, Goisern, St. Agatha, Hallstatt, and Aussee with the electric light. What difficulty would there be in using the numerous waterfalls for charging accumulators, by means of which the passenger traffic on the lakes of the Salzkammergut could be efficiently managed?

In the Harz a syndicate is about to build an embankment across the Bodethal, and thus partly alleviate the inundations, and at the same time utilising the water power electrically by means of turbines for the adjacent towns, Thale, Quedlinburg, and Blankenburg. The cost is estimated at 2,000,000 marks. At Lagenthal, in Switzerland, 3,000 H.P. are being obtained from the Aai for a light and power installation.

The Alpine waters promise not alone vast advantages to the inhabitants on the large scale in return for the damage which they at times occasion, they offer even to small peasant communities the advantages of the electric light when it can be obtained from an adjacent waterfall.

A very curious electric company has been formed at the village Faide, on the Gotthard railway, a place numbering 1,000 inhabitants. It obtains from the torrent Pinmogna a small supply of water (35 litres per second) by means of an iron pipe of 150 millimetres in diameter, which drives below a small high pressure turbine, which, with a pressure of water of 145 metres, evolves 45 H.P. The turbine drives a dynamo, which supplies the little village with 360 glow lamps. The whole costs 40,000 francs, which are divided into shares of 250 francs each, the owners of which form the company. In this manner, in addition to the streets and the railway station, the peasants and working men have their houses supplied very cheaply with the electric light, which is elsewhere regarded as a luxury.

FURTHER RESEARCHES ON THE ELECTRICAL BEHAVIOUR OF PRECIPITATED MEMBRANES.

IN our issue for January 9th, we gave some account of Ostwald's researches upon the electrical properties of semi-permeable walls, the term "semi-permeable" having reference to the property possessed by some materials of allowing the passage through it of any given solvent, but not of a salt that may be dissolved in it. This property of permeability appears to depend, not upon the nature of any given salt as a whole, but upon that of each of its ions. Semi-permeable walls exert a selective influence upon the ions, allowing some to pass, but preventing the passage of others, and from the results of his experiments, Ostwald deduced a theory concerning this peculiar behaviour, which may be used to explain many interesting phenomena, amongst them being some of an electro-physiological nature.

Ostwald's paper was given in full in the *Zeit. Physikalische Chemie*, t. vi., p. 71, and there was a paper bearing upon the subject in the *Monatsberichte Berl. Akad*, by Dubois-Reymond (1860, p. 816), which seems almost to have been forgotten.

Ostwald's paper was quickly followed by an investigation, undertaken by G. Tamman, into the conductivity of precipitated membranes, and the results were duly reported in our issue for April 3rd, the original paper having been published in the *Zeit. Physikalische Chemie*, t. vi., p. 237. Tamman's "membranes" were perhaps what would be ordinarily termed "films," such, for instance, as would be formed when a solution of sulphate of copper is gradually poured upon the surface of another solution of potassium ferrocyanide; in this case the "film" would be, strictly speaking, a precipitate of ferrocyanide of copper.

The interesting results which have been obtained by Ostwald and Tamman in this field of research, have attracted the attention of other physicists. In the *Annalen der Physik und Chemie*, there is a paper by A. Oberbeck, in which he describes some experiments that he has been carrying on with a view to studying the electrical behaviour of these precipitated membranes. His *modus operandi* was as follows:—

Two tubes of glass were closed each at one end with parchment paper, and then filled up with an aqueous solution of a zinc or copper salt. They were then immersed in a beaker in which had previously been placed an aqueous solution of a salt which was of such a nature as to give a precipitate with either the acid radicle or the metal of the salt in the tubes. The precipitate forms within the parchment paper,

and the electrical properties which it exhibits are comparable to those observed by Ostwald and also by Tamman.

Now, Oberbeck approached this interesting subject from a slightly different standpoint. His object was to measure quantitatively the polarisation caused when such membranes as those described above were introduced into an electrolytic circuit.

In studying the polarisation, Oberbeck introduced into the two glass tubes rods of amalgamated zinc if a solution of a zinc salt were employed, and rods of copper when a solution of a copper salt was used, and these rods served as electrodes. The primary current practically produces no polarising effect whatever upon these electrodes, hence if any polarisation did occur, it was obviously due to or had its origin in the precipitated membranes.

Polarisation was observed, and it was measured separately, with the result that nothing of any consequence could be found except at that membrane where the precipitate was thickened by the action of the electric current. For instance, when sulphate of copper solution filled the two tubes and a solution of potassium ferrocyanide was placed in the beaker, the ion Fe C_6 N_6 travels to the tube containing the anode, and consequently strengthens the membrane by meeting the copper ion there; on the other hand, the potassium ion K meets the ion SO_4 in the membrane at the cathode, and no precipitate is formed.

The term given by Oberbeck to such a membrane as that which we have just described, viz., copper ferrocyanide, is an "anodic" membrane. Similarly, when lead sulphate is formed at the tube containing the negative electrode, the beaker being filled with a solution of a lead salt, it is called a "kathodic" membrane. When copper salts are used with ferrocyanide or ferricyanide of potassium, an electromotive force of polarisation is obtained which rises to a maximum of about 1 volt. Owing to the thickening of the membranes and the consequent increase of the electrical resistance, the primary current becomes much weaker as it flows.

Oberbeck tried porous clay cells instead of parchment paper over the ends of the tubes, and these were found to offer much less resistance, so that the electromotive force of polarisation was much greater in this case, and corresponded with the increased current density.

A polarisation was observed with zinc salts only about half that with copper salts; in this case the phenomenon depends on the kation.

Interesting results were obtained with lead salts. When an aqueous solution of any of these was used in the beaker the polarisation electromotive force rose to 2 volts. At the kathodic membrane spongy lead separates, and in consequence of this probably the current increases.

The following quantitative results were also observed :—

Salts.				Polarisation electromotive force.
Calcium chloride	against	zinc sulphate	...	+0·08
Strontium "	"	"	...	+0·39
Barium "	"	"	...	+0·73
Silver nitrate	"	"	...	−0·24
" "	"	copper sulphate	...	−0·26

It may be remembered that Tamman found some variations between permeable and impermeable membranes when the currents were long continued, but Oberbeck is unable to find any characteristic difference in their behaviour under such circumstances: such differences as were observed by Tamman he considers to have been due to the rapidly alternating currents which he employed in his investigation.

THE DETERMINATION OF THE DIELECTRIC CONSTANT OF GLASS BY MEANS OF VERY RAPID ELECTRIC OSCILLATIONS.

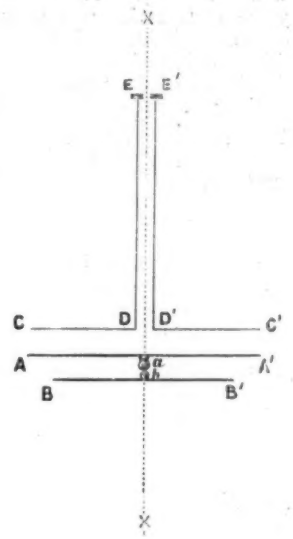
RAPID electric oscillations were employed by J. J. Thomson in 1889 in the measurement of the dielectric constant (*vide Proceedings of the Royal Society*, June 20th, 1889). But the conclusions which he drew from the results of his investigation were said by some to have been erroneous, on account of his having employed a formula of alleged doubtful accuracy for giving the period of the oscillations.

Quite recently E. Lecher has measured the dielectric constants of several substances by means of a method based upon the determination of the wave length of very rapid oscillations, and without employing the formula used by Thomson. The conclusions arrived at in this case were diametrically opposed to those of the English physicist.

R. Blondlot has been attracted to the study of the same subject, and in investigating the dielectric constant of glass he has been employing a method also depending upon very rapid oscillations, but independent of the formula used by Thomson. His work was described in a paper before the Paris Academy of Science on May 11th (*vide Comptes Rendus* t. cxii., p. 1,058). The following short account comprises the essential features of his investigation).

A large rectangular sheet of brass, A A′, is fixed in a vertical position; a second plate, B B′, of rather smaller dimensions, forms with the first a kind of condenser. This condenser can be discharged upon itself by means of the knobs, *a* and *b*; *a* is in communication with the gas pipes, and *b* with one of the poles of an induction coil, the other pole being also connected up with the gas pipes.

When the coil is working, the condenser, A B, is the seat of oscillatory charges and discharges, of which the period is of the order of $\frac{1}{250000000}$th second. Thus in the space situated on the side of A A′, opposite to B B′, there is a



periodic electro-magnetic field, which has a plane of symmetry along the line, X X.

If we fix in this field two square plates, C D, C′ D′, parallel to A A′, and symmetrical with regard to X X, having at D and D′ two straight wires soldered and arranged as in the figure, with their free ends terminating at E and E′ in two carbon points, which are separated by a small space; then when the coil is in full work, no sparking will be observed between E and E′. But if between A A′ and C D there be interposed a plate of glass, at once brilliant sparks will pass between E and E′, because the induction of C D is greater than that of C′ D′.

Now, if between A A′ and C′ D′ a plate of sulphur be placed, of such a thickness that the inductive action on C′ D′ may be equal to that on C D, the sparking between E and E′ will disappear. And since this disappearance of sparking between E and E′ will indicate that the induction of C D is equal to that of C′ D′, it will suffice to measure the thicknesses of the two dielectric plates, in order to determine, by an easy calculation, the dielectric constants of the glass and the sulphur.

Mons. Blondlot claims to have made this interesting method of examination both sensitive and accurate by taking certain obvious precautions.

The plate of glass employed was exactly 3 cm. thick. Two plates of sulphur were used; they were cast in the form of prisms, having the same angle as in the Babinet compensator; by shifting them the thickness could then be varied at will. A thickness of sulphur 3·15 cm. exactly compensates for the 3 cm. thickness of glass.

A knowledge of the dielectric constant of the sulphur is

necessary in carrying out this experiment. By using the method pointed out by J. Curie (*vide Annales de Chemie et de Physique*, 1889) Blondlot found this value to be 2·94, and hence the dielectric constant of glass was found to be

$$K_{glass} = 2{\cdot}8 = (1{\cdot}67)^2$$

This value is almost identical with that obtained by J. J. Thomson.

Maxwell's law is not, however, verified exactly, for the mean index of the plate of glass used by Blondlot was about 1·51, but the square of this number is by no means so great as that value given by the slower methods for the dielectric constants, and hence Blondlot arrives at the same conclusions as those deduced by J. J. Thomson and rejects Lecher's results.

THE POLLAK-BINSWANGER CLOSED CONDUIT SYSTEM.

AT a recent meeting of the Berlin Electrotechnical Society, M. Pollak, of Paris, described a direct system of electric traction with underground conductor, patented by himself and Mr. G. Binswanger in 1886. The interest and necessity for such a system at that time were so small that no efforts were made to make it known, but now that electric tramways are exciting considerable attention, it was thought advisable to publish details of the method. The system is of the closed-conduit type, and consists in the use of an ordinary rail on one side of the line, and of two parallel rails on the opposite side. These parallel rails are laid in sections of from 3 feet 4 inches to 5 feet, and are in electrical but not in magnetic communication with each other. Each pair of rails is suitably insulated from the sections in front or behind. Under these rails, but not in contact with them, is arranged a copper conductor, which is connected with the generating source and the track or running-rails. Lying on the surface of the conductor and at short distances apart is a number of strips of iron, or contact pieces, one end of each of which is fastened to the conductor, whilst the other end is free and almost in contact with the parallel rails. If a magnet, preferably of the horseshoe type, is placed over the rails, the free ends of the contact pieces are brought into communication with the under portion of the rails, and the current can then be collected from the latter. The car carries a magnet of this type, together with an electromotor, regulating apparatus, &c. As the sections of rails are less than half the length of the car, there is no danger in fine weather to passers-by who may step on the rails either in front or in the rear of the car. The loss of current, states the author, through the shortness of the rails, is insignificant, and may be completely disregarded in practice. There are two contact pieces under each sectional rail, and the magnet is so extended that as the car travels the contacts of one sectional rail remain attracted, whilst those of the other are being attracted, thus obviating sparking.

The inventor states that it is easy to understand that even metal rods laid transversely could not cause a short circuit or an interruption in the service, that the working is entirely safe, that the cost of laying down the system is less than that of an open conduit type, and that the system might be considered perfect. Unfortunately, it was soon found that it was impossible to establish and maintain a perfectly watertight conduit in the streets, that the lengths of parallel rails and iron strips (even if the latter are tinned) become rusty, that a good contact is very questionable, that in rainy weather passers-by are liable to receive shocks through the formation of short circuits due to moisture, that the iron strips become frozen in winter time, that the magnet will no longer attract, and that the service must be discontinued. Notwithstanding these defects, M. Pollak considered the system to be good, and he set to work to remove the former, with the result that in 1887 considerable modifications were introduced. In this improved system the conductor has a lead covering, it is embedded in a wooden, stone, or cement channel, and is surmounted by other insulating material. From this conductor lead-covered branches are led to the inside of hermetically closed boxes made of non-magnetic metal, but the branches are not in electrical contact with the boxes. Inside each box, of which there are two fastened to the under part of each sectional rail, is a movable contact piece which, as the car passes along the line, is put into communication with the branch conductor and the sectional rail from which the current is collected.

With this system the cable can be laid near the rails, and it can be very small, and fed here and there from a main cable. The contact boxes are made for the passage of up to 100 ampères, and as they are hermetically sealed and no sparking occurs, the contacts remain good and reliable; moisture has no effect, and the service can be maintained in cold, frosty weather. Arrangements are provided whereby the car can be removed from the track and placed upon it again over 50 yards further on in case any serious obstacle be found on the line. In order to show the working of the boxes and the system generally, M. Pollak exhibited and set in operation a model. The extended magnet carries two brushes which collect the current from the rails; the current passes to the motor through the wheels to the track or running-rails back to the generating dynamo.

THE FRANKFORT ELECTRICAL EXHIBITION.

No. II.

THE Frankfort Exhibition comprises the following distinct departments, several of which are a considerable distance from the principal scene :—

1. The Exhibition Grounds close to the Central Railway Station, with an area of 77,000 square metres, of which 21,200 square metres are covered with buildings. The most noteworthy of these buildings are the machinery hall, the boiler house, the hall for telegraphy and telephony, the hall for conducting and distributing cables and material, the hall for installations, the hall for railway material, the hall for medical and scientific instruments, the hall for electrochemistry, the hall for parts of machinery (engineer's sundries), and the workshop buildings containing all kinds of machines and tools operated by electric motors.

2. The maritime exhibition on the river Main, with a lighthouse and several electric boats, the largest of which is constructed to carry 100 passengers.

3. The captive balloon on the square in the Kaiser Strasse. Winding gear actuated by electric motor.

4. The installation in the Palm Gardens, which furnishes electric energy for the exhibition grounds.

5. The electric tramway leading from the principal exhibition to the maritime exhibition. This line is worked with overhead and underground conductors.

6. The electric tramway running from the exhibition grounds to the Opernplatz; this is worked with cars deriving their energy from overhead conductors as well as with accumulator cars.

7. The Frankfort Waldbahn, worked with storage battery cars which are charged in the exhibition.

8. The installation for electric transmission of power at Offenbach (10 kilometres distant), which supplies energy to numerous motors in the principal exhibition.

9. The waterpower and electric installation at Lauffen (175 kilometres distant), transmitting 300 H.P. to the Frankfort Exhibition.

10. The telephonic transmissions of music, viz.: from the pavilion of music in the exhibition to the car of the captive balloon; from the music room of the military band in the Frankfort Infantry Barracks; from the stage of the Opera House in Frankfort; from the stage of the Royal Theatre in Wiesbaden; from the stage of the Court Theatre in Munich; from all of these the delightful sounds are transmitted to numerous isolated chambers in the telephonic hall of the Exhibition.

Contrasted with the Paris Electrical Exhibition of 1881, one is struck with the fact that the Frankfort show does not bear the international character in anything like the same degree. England and America were largely and thoroughly represented at Paris with all their best productions. But we have here a splendid demonstration of the vast strides made in the electrical industry by Germany and Switzerland. These countries have made an immense effort to prove their

capacities to the world, and we have no doubt that the Frankfort Exhibition will lend German and Swiss enterprise additional importance in the foreign markets. Out of ten English exhibitors, three are engine and boiler makers; one a glass cutter and spinner applying electric motors to his tools; one firm shows ventilators worked by electric power; one insulators; another incandescent lamps, made in Germany; one of our largest telegraph companies exhibit samples of their instruments, and finally one of our general electric supply firms, through their Hamburg agency shows sundry fittings, bells and instruments. We shall return in detail to the exhibits of these firms which, however, are all of secondary importance as regards novelty or magnitude. None of our largest manufacturing concerns have accepted the invitation of the Frankfort Exhibition Committee, and this leads to the conclusion that Englishmen have grown tired of international exhibitions—not in the capacity of visitors, for Paris in 1889 proves the contrary—but as participators in the race for fame and notoriety. France, as a matter of course, is not represented. Austria sends a fair number of exhibits but we miss two of the most prominent firms. The United States of America were satisfied to be represented by four exhibitors. Altogether there are nearly 500 exhibitors mentioned in the catalogue, 100 of which have only sent drawings and designs of a technical character. With the above, and a few other exceptions, Germany commands the field in a manner worthy of every praise, and no electrical engineer who can afford the time, should miss this opportunity to inform himself of the activity, workmanship and style of his continental confréres and competitors.

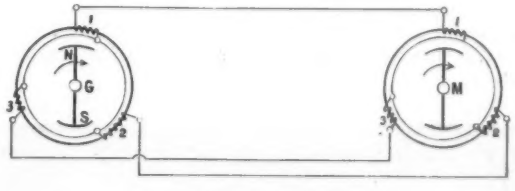
Much attention is being directed to certain systems which the Germans designate "Drehstrom," and for which a short English expression will have to be coined before long. Perhaps Dr. Fleming will be good enough to invent an appropriate name for it. This "Drehstrom System" is a multiphase transmission which will be adopted in the experiment between Lauffen and Frankfort, and which is carried out jointly by the Portland Cement Works at Lauffen, which puts its 300 H.P. turbine at disposal, the Maschinenfabrik Oerlikon, and the Allgemeine Elektricitäts Gesellschaft, which supply the dynamo, transformers and instruments at the generating station, motors and insulators, and lastly the Government which undertakes the erection of the conductors —three wires of 4 m.m. diameter, each of 175 kilometres in length. The intention is to work with a pressure of 25,000 volts. The German Emperor has granted 10,000 marks towards a portion of the cost of the leads. The two companies supplying the electrical plant have guaranteed under a penalty of 51,000 marks to have the installation in working order at or before the middle of August next. For this transmission 2,600 telegraph posts, 9,000 fluid insulators and about 60 tons of copper wire will be used. The details of the design are carried out by Mr. Brown, of Oerlikon, and Mr. Dobrowolsky, of Berlin.

No practical data, giving one a clear idea of the working efficiency of this system has as yet been made public. Mr. Dobrowolsky has recently given a general explanation of the "Drehstrom System" in the *Elektrotechnische Zeitschrift*; Dr. Epstein lectured upon it before a meeting of the Electrical Society of Frankfort; and Mr. Haselwander supplies an elementary sketch to *Elektricität*, the official exhibition journal. Dr. Epstein endeavoured to explain away the false notion that we have here to deal with a new kind of electric current, and emphasised the fact that we have still only the continuous and the alternating current. But the multiphase generator gives a combination of alternating currents which cannot be produced in the simple alternator nor by a direct current dynamo. The arrangement is such, that the alternating currents developed in distinct and separated coils on the armature are opposed in their phases, and are each separately led to the points of application; the E.M.F. of each current starts from zero up to the positive maximum, again through zero to the negative maximum, not for all the currents simultaneously, but at intervals which bear a certain relation to one revolution of the machine; the successive currents change their *rôle* in cyclic order, and the sum of the E.M.Fs. of the system is a constant quantity. Comparing the three-wire continuous current system, with the three-phase ("Drehstrom") system, we have in both cases three wires; but in the former case, the potential difference between two neighbouring wires is only half that between the outer leads, whereas the mean potential between any two wires of the three-phase system is the same. In the multiphase circuit we have, as in the case of a continuous current circuit, a steady flow of energy which is assumed to be constant. The individual currents, however, which produce the sum of effects, are distinct alternating currents capable of being converted through a stationary transformer.

The particular advantage of this system must be found in the fact that all the circuits have the same value; *i.e.*, a group of incandescent lamps may be joined to any one pair of leads. Moreover, electric motors, constructed on this principle, are exceedingly simple, start from any position, and do not come to a standstill in the case of temporary overloading for short periods of time, because it can never occur that all the leads are without current. Referring to the history of this system, the original idea emanates from Professor Ferraris, of Turin; Mr. Tesla made some practical use of it in the year 1888; he demonstrated the branching off of separate alternating currents of different phase from a single armature, but he had to use for n currents, first $2n$, and later $n + 1$ leads. In the following years, and almost simultaneously, Bradley, of New York, Haselwander, of Offenburg, Dobrowolsky, of Berlin, and Wenström, of Stockholm, made further improvements which permit of the number of leads being equal to the number of currents. The word "Drehstrom," although misleading, has its origin with Mr. Dobrowolsky, and he justifies the expression (rotary current, literally translated) by the following phenomena: taken a compass needle surrounded by a coil; a continuous current sent through this coil gives the needle a definite deflection; the alternating current causes the needle to vibrate in the north-south position; the "Drehstrom," however, gives the needle a rotary motion. But it is also possible to give the needle a rotary motion with the current of an ordinary alternator. The expression is open to many objections, and the system should be renamed.

The following description is due to Mr. F. Haselwander, one of the earliest workers in this field, and who has applied for patents and showed the system in operation in the month of June, 1888.

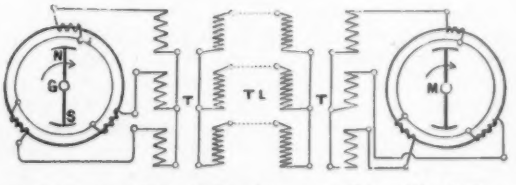
Fig. 1 shows diagrammatically the arrangement of generator, motor and leads. Both machines have a stationary armature and rotating fields. For the sake of simplicity, only three bobbins and two poles are indicated.



G, Generator; M, Motor.

FIG. 1.

Fig 2 represents the same machines with transformers interposed between the three transmission leads. Instead of the three phases, two or more can be arranged; the inter-



G, Generator; M, Motor; T, Transformers; T L, Transmission leads.

FIG. 2.

linked three-phase current is simply the solution of the problem, to obtain with a minimum of transmission leads, the largest number of currents of different phases. Any continuous current machine can, after removing the commutator and substituting in lieu of its segments half the number of transmission leads, be converted into a multiple-phase

machine. It is immaterial whether we rotate the field or the armature. The first machine of this kind was tried in October, 1887. This had a fixed armature made in the form of a ring out of iron wire; this ring was 400 millimetres in diameter, 180 mm. broad and 30 mm. thick. It was wound with 12 bobbins, each bobbin of 52 turns; the copper wire being 1·5 mm. thick. The ends of the bobbins were led to terminals fixed round a wooden disc. These terminals could be joined in a variety of ways, so that the machine was capable of giving 50 volts at 48 ampères; 100 volts at 24 ampères; or 200 volts at 12 ampères, with 960 revolutions per minute. Within this armature was a four-pole magnet keyed to the rotating shaft; the cores were 80 mm. in diameter and 80 mm. long, including pole pieces. The winding of these magnets consisted of 672 turns of copper wire 1 mm. diameter on each of the four cores. The armature and bearings were supported by a strong cast iron frame. The total weight of the machine was 303 kilogrammes. Each kilogramme of copper wire gave an output of 160 watts. For the purpose of self-exciting there was a commutator, which was sparkless with a constant load.

Messrs. Lahmeyer & Co. exhibit several of these machines, of more modern construction. The transmission of power between Offenbach and Frankfort (10 kilometres) is carried out with this system. Visitors to the installation at Offenbach can obtain tickets of admission, free, by applying to the representative of the firm in the Exhibition.

PROF. EWING'S THEORY OF MAGNETISM.*

By ARTHUR HOOPES.

THE "Theory of Induced Magnetism" which Prof. Ewing published in the *Philosophical Magazine*, for September, 1890, is at once so beautifully simple and comprehensive that we have thought that some magnetisation curves actually obtained from the model which he suggests might be interesting as testing, in some degree, the efficiency of the hypothesis. With this end in view the accompanying curves were determined by the writer, under the direction of Dr. Henry Crew, of Haverford College.

The magnets used were similar to those described by Prof. Ewing, about two inches long and balanced on sewing needles set in lead bases. They were 68 in number, and were placed in three layers or tiers on glass plates, which slipped into the magnetising coil. The coil was 32 inches long and 12 in diameter, and was wound from end to end with 76 turns of wire. It was set with its axis east and west.

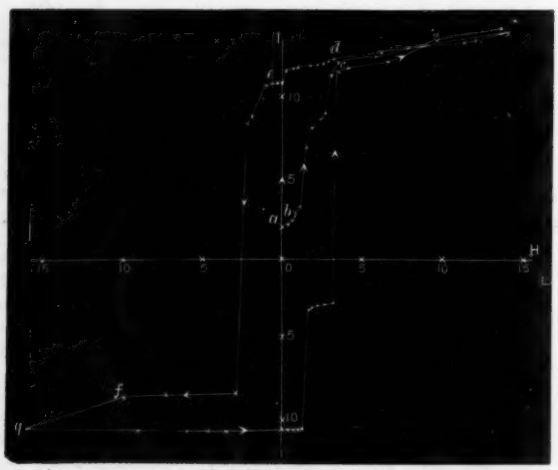


FIG. 1.

The magnetic moment of the model was measured by a magnetometer 34 inches from the middle of the coil. To eliminate the magnetic effect of the current in the coil, an opposing coil was adjusted on the other side of the magnetometer, at such a distance that it just balanced the large coil when the magnets were out. The maximum strength of field used was about 2·7 C.G.S. units, or 15 times the horizontal component of the earth's field.

The method of obtaining the curves was simply to put in the magnets, stir them up and let them come to rest by themselves, then to vary the magnetising current through a cycle and read the magnetometer deflections at intervals. As no attempt was made to get anything but the *shape* of the curves, the tangents of the magnetometer and galvanometer deflections were plotted on a convenient scale, without regard to the absolute values of current and magnetic moment.

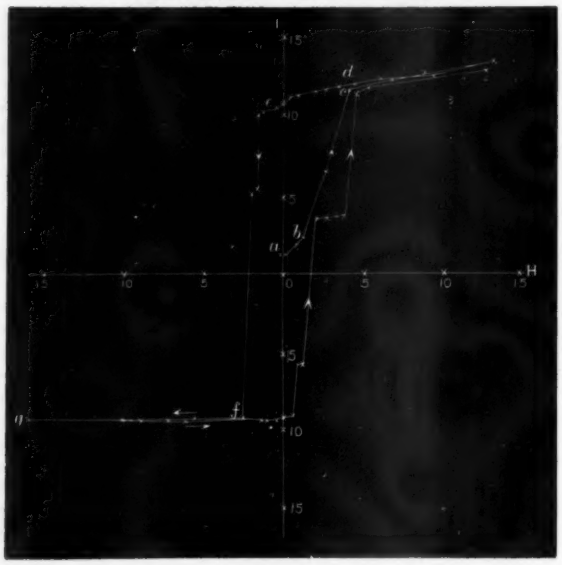
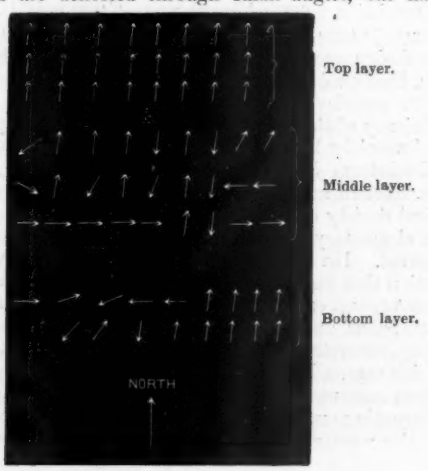


FIG. 2

Figs. 1 and 2 show curves obtained with the magnets as close together as they could be placed without striking. They illustrate well the different results that may be caused by different initial directions of the magnets. The magnet *centres* were in almost the same positions in the two cases, but in fig. 1 the magnets took the directions shown in fig. 3, while for the curve of fig. 2 the original state is shown by fig. 4. Both curves show beautifully the small susceptibility at first (*a* to *b*, figs. 1 and 2), where the magnets are deflected through small angles, but have not yet passed through an unstable position. From *b* to *c* the magnets turned rapidly with small increase of current, and from *c* to the right they were brought more and more nearly into the direction of the axis of the coil, giving the flat part of the curve. On decreasing the current the curves almost retrace themselves to the point *d* directly above *c*,



Direction of magnets corresponding to the curve in fig. 1.

FIG. 3.

* *Electrical World.*

where stability begins. But here it leaves the ascending branch because it takes less strength of field to *hold* them in this position than it required to *put* them there. This state continues until the field is of nearly zero strength, when two or three magnets turn, giving the small drop at *e*. A slight negative increase turns many more, and another reverses every remaining magnet except four, which are almost exactly opposite to the direction of the field. In fig. 1 the

Direction of magnets corresponding to the curve in fig. 2.

FIG. 4.

increase from *f* to *g* turned these four, but in fig. 2 they were not affected by the strongest current that could be used. Consequently the curve of fig. 2 is almost horizontal between *f* and *g*. The difference was probably due to a slight change in the position of the plate which supported these magnets. Completing the cycle, the upward branch of fig. 1 is seen to consist of two main steps, while fig. 2 has three, and both curves are to the right of the origin.

These curves may possibly represent one group of molecules in a steel bar. Since the mean density of steel is nearly the same as that of iron, it appears that the large hysteresis of the former is due to the molecules in individual groups being nearer, the groups themselves being further apart than in soft iron. To diminish the hysteresis of the model, the magnets

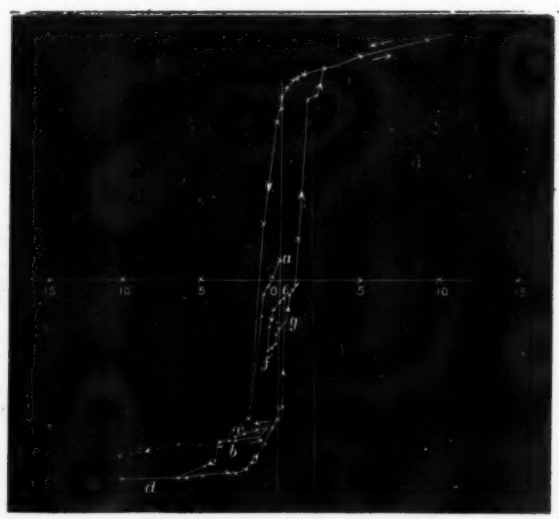


FIG. 5.

must be placed further apart in order to lessen the stability of their positions. The area of the curve can thus be decreased indefinitely. The curve of fig. 5 was taken with the magnet centres 2½ inches apart—that is, with the magnet ends ½ inch apart at the closest. In this curve the cycle was performed in the opposite direction to that of the others. The last downward branch is dotted to distinguish it from the first. The area of the curve suggests at once that if figs. 1 and 2 represent the case of steel, fig. 5 represents soft iron—that is, the case in which there is a less intimate connection of the molecules in their respective groups.

At *b* a small cycle* was superposed upon the main cycle, as shown by the small loop. At *c* the loop returns to the main curve. If one of these minor cycles be performed at a point like *d*, which represents a stable position of the magnets, the curve merely retraces itself, illustrating the fact that there is no hysteresis without passing through a position of instability. On the contrary, at a point like *e*, where nearly half of the magnets have just turned, the area is very large. It is interesting to note that the curve took a new track at *g* instead of returning to *e*.

These are a few of the curves which have already been obtained from the model. They are necessarily very imperfect, largely on account of the relatively small number of magnets used. They suffice to show, however, the close resemblance of the model to actual magnetic metal, as far as the most important properties are concerned, which was all that was originally expected.

THE ELECTRICAL TRANSMISSION AND CONVERSION OF ENERGY FOR MINING OPERATIONS.†

By H. WARD LEONARD.

THE transmission and conversion of energy is, above all others, the question of importance in every kind of engineering work, and in mining engineering this is most conspicuously true.

Until quite recently all practical methods of transmitting and converting energy involved the actual transfer of sensible matter over the distance in question and this matter necessarily possessed such qualities as weight, magnitude, temperature, inertia and other qualities common to all matter.

It is, therefore, not surprising that all engineers, and particularly mining engineers are watching with the keenest interest the development of methods for transmitting and converting energy by means of electricity, for, in electrical problems, the many considerations and restrictions due to the inflexible characteristics of matter may be entirely disregarded and the possibilities of mining engineering are correspondingly increased.

The transmission and conversion of energy by water, steam, cables, compressed air, and so forth, we are all familiar with, and we know to our sorrow the limited distance, the low efficiency or the tremendous first cost which has hampered our engineering work at every turn.

With the utilisation of electricity for the transmission and conversion of energy we absolutely reverse these conditions and are enabled to operate at practically unlimited distances, with extremely high efficiency and very low first cost.

The invention of the incandescent lamps marks the commencement of an era upon whose threshold we now stand and in which the possibilities of engineering will be extended to a degree we can, at present, have no adequate conception of. Until the Edison lamp was invented and introduced, all distribution of electrical energy was by what is known as the series system, which did not lend itself readily to the development and use of electric motors. With the Edison lamps came the system of distribution on the multiple arc plan, and the commercial possibility and development of electric motors dates from that time.

The stationary electric motor supplied from the lighting circuit was naturally the first on account of the number and simplicity of its applications; then the motor was applied to propelling street cars, and the modern electric street railway system was rapidly evolved. The electrical engineer, in his search for "new worlds to conquer," next turned his attention to the mining field.

The great variety of the applications in this field, the distances from the mines to the principal cities where electrical developments have been most rapid, and the lack of knowledge as to the exact requirements have, until recently, made even the simplest applications of electricity to mining rather rare.

Perhaps the greatest stumbling block has been the percussion drill. Until recently, when a mine owner asked if we could transmit his power, light his mine and operate his pumps, hoists, tramways and mills, we could confidently reply "yes"; but when he asked if we could replace or operate his air drills we were obliged to say "not yet."

Since the drill is the most universal of all mining appliances operated by power other than hand power, it was not possible to make rapid progress until this deficiency was corrected.

The Edison General Electric Company has put upon the market in commercial form, during the past 30 days, three types of electric drills which will enable the mining engineer to accomplish all that he has been able to accomplish heretofore by other drills, and not only this but to accomplish far more than was heretofore possible and under conditions heretofore prohibitory.

* Lord Rayleigh, *Philosophical Magazine*, March, 1887.

† Read before Association of Mining Engineers of the Province of Quebec, April 29th, 1891.

First in importance comes the electric percussion drill, the invention of H. N. Marvin, of Syracuse.

Following is a brief description of the principal features of the drill:

Fastened upon a suitable tripod or column is a piece of boiler tube 7 inches in diameter and about 2½ feet long. In the forward half of this casing are placed two cylindrical coils of wire in the form of solenoids, each about 8½ inches long, having an outside diameter of about 6¾ inches, so as to make a loose fit with the casing, and an inside diameter of about 2⅛ inches. These two solenoids are placed so as to be against each other end to end in the casing. The bit plunger plays freely through the centre of these solenoids, and is supported by two bearings placed just beyond the outside ends of the two solenoids respectively. The back portion of the casing contains a spiral spring of the form frequently used for car springs. The plunger is composed of a central portion made of wrought iron, about 14 inches long, and both the forward and back portion of the plunger, which are made of aluminum bronze, are rigidly fastened to this iron portion. The forward portion is about 13 inches long, and carries the bit socket. The back portion is spirally milled for a length of about 9 inches, so that the cross section of this portion is hexagonal. At the extreme back end is a steel buffer which strikes against the cushioning spring.

The spirally milled portion of the plunger is similar to that used in other purcussion drills, and causes the drill to revolve upon its axis one-sixth of a complete turn with each stroke. The ends of the coils of wire are brought to contact pieces at the top of the adjacent ends of the two solenoids, where there is a socket for receiving the terminals of the cable and thus making electrical connection with the drill. There are three conductors leading from the generator to the drill, one of which is connected to one terminal of each of the solenoids, and the other two conductors are connected to the two remaining terminals of the solenoids respectively.

The generator is of the simplest kind, the coils on the armature having their terminals connected to two insulated collars on the shaft.

One collar is a continuous metallic ring, and upon this one rests a brush which is connected with the conductor, which is common to both solenoids. The other collar is metallic for half of the circle, and the remaining half is insulated from the armature wires. Upon this half ring rest two brushes diametrically opposite each other, and each brush is connected to one of the two remaining conductors leading to the solenoids in the drill.

If we now revolve the armature of our generator in a separately excited magnetic field, an electric current will flow, let us say, from the armature to the half ring, then through one of the two brushes which happens at the instant to be in contact with the half ring, along the corresponding conductor to one terminal of one solenoid, let us suppose the rear one. Then through the rear solenoid itself and back along the mutual wire to the continuous ring and then to the armature again.

This current in passing through the rear solenoid makes a powerful magnet of it, and this tends to pull the plunger back into a position such that the centre of its iron portion shall be in the centre of the rear solenoid.

When the armature moves forward a half revolution, the polarity of its wires is reversed, and the other brush with its conductor is now in contact with the half circle. Consequently, the current in the mutual wire will be in the reverse direction from that of the former wave, the rear solenoid and its conductor, formerly active, are now out of circuit, and the circuit is made through the other conductor and its corresponding solenoid, that is, the forward solenoid.

The magnetic action of this solenoid now tends to make the plunger move forward so that the centre of the iron portion shall be in the centre of the forward solenoid.

Thus we get a reciprocating action of the plunger, and every revolution of the armature of the generator will cause a complete stroke of the drill. By varying the speed of revolution of the generator we can make the drill strike any number of blows per minute we choose. In usual practice 600 blows per minute is found to give excellent results. The spiral spring, it will be observed, stores up the energy of the back stroke and returns it to the forward stroke, assisting the magnetic impulse and greatly increasing the strength of the blow.

In order that we may form an unbiassed judgment of this drill, I will quote the opinion of Andre, perhaps the best authority on power drills, and who many years ago stated the requirements of a first-class power drill to be as follows:—

1. Simple in construction, strong in every part.
2. Few parts, especially moving parts.
3. As light in weight as can be made strong.
4. Take up little space.
5. Striking part of relatively great weight and strike directly.
6. Piston alone exposed to shocks.
7. Piston capable of variable length of stroke.
8. Sudden removal of resistance should not injure any part.
9. The rotary motion should be automatic.
10. The feed of machine, if automatic, should be regulated by the advance of the piston as the cutting advances.
11. Should be capable of working with moderate pressure.
12. Should be readily taken to pieces.

It may be sufficient to say that the Marvin drill possesses every one of the good qualities Andre specifies, and in a most marked degree; but, in describing the good qualities of this drill, we can, if necessary, add considerably more than Andre specifies, for example:—

1. It is simple in construction and strong in every part.
2. It has a minimum of moving parts, that is one.
3. It is very light in weight for its strength, this being possible because of the perfect cushioning at both ends of the stroke.
4. It takes up very little space.
5. The striking part is of relatively great weight and it strikes directly.
6. The length of the stroke is variable at will.
7. The drill cannot damage itself by its own blow.
8. The rotary motion is automatic.
9. It has very few parts.
10. It can be entirely taken apart and put together again inside of ten minutes.
11. There are no joints to be fitted or packed.
12. It is not affected by heat or cold.
13. It can be operated at great distances from the source of power.
14. It has a much higher efficiency than other drills.
15. It is independent of the action of any valve.
16. The rate of striking is independent of the kind of material it strikes.
17. It will operate in the open air without striking anything, and hence can be made to strike an extremely light blow at its full rate, which is very important in starting holes, and so forth.
18. It can be rapidly moved from one position to another at a great distance, since the energy is transmitted through flexible cables.
19. No loss is suffered due to elbows, bends, valves, and so forth, in the conductors.
20. The conductors can be carried on very light supports, both because of their light weight and because the transmission of energy through them does not tend to distort their position.

The importance of the above characteristics will be apparent to any one who is familiar with the operation of the steam and air drills.

It is interesting to note that in driving the Hoosac Tunnel the average life of the power drills, before sending them to the shop, was 50 hours. Even to-day, after a development of 25 years, we find that it is common practice to have in the shop one half the total number of drills employed.

In pushing engineering work it is frequently of paramount importance that the work be done quickly. Therefore, any means of greatly increasing the rate of drilling is extremely valuable. To increase the rate of drilling, we must either increase the strength of each blow or else we must increase the number of blows per minute. A limit to the rate of striking is soon reached when a valve of considerable weight must be moved from rest by the concussion of the previous blow, and when a material substance, such as air or steam, must then fill the space back of the piston and raise the pressure to the working pressure. Also the strains and shocks caused by the valve and the air or steam soon become troublesome as we increase the rate of striking. With the electric drill the speed of rotation of a perfectly balanced cylindrical armature of small diameter has no such limitations, and there is apparently no limit to the rate of striking, except the magnetising and demagnetising of iron, which is already done in daily commercial practice at the rate of 10,000 times per minute with the highest efficiency.

With 800 blows per minute we have already drilled, at the rate of 4 inches per minute, a hole 1½ inches in diameter in the hardest Quincy granite, and that with an expenditure of energy not exceeding 3 horse-power.

I firmly believe that in a comparatively short time we will be furnishing percussion drills whose rate of striking will be several times as much as that we now employ, and that with no more and no heavier drills than are now used, the rate of driving a heading will be increased many times. The importance of rapid driving of work is practically illustrated by the fact that in driving the Sutro Tunnel, Mr. Sutro offered the men at work, in addition to their regular wages, the following bonus:—

For every foot per month over	300	and under	400	$5.
"	"	"	400	"	500	$10.
"	"	"	500	...		$20.

A bulletin from the Census Department, under date of March of this year, shows that in granite quarrying the cost of labour is 64 per cent. of the total cost of production; and in Massachusetts, where the output is much greater than in any other State, and where the longest experience and most approved methods are met with, the labour is 82½ per cent. of the total cost. It will be evident that any labour-saving device in such a field will be extremely valuable.

Another drill of great value to the mining engineer is the diamond drill. The Edison General Electric Company have, during the past thirty days, put upon the market an electric diamond drill which they have been developing for the past two years. The drill is the invention of I. E. Storey, of Denver. It presents a great many advantages over the diamond drills heretofore used, as will be evident from the following description of it:—

The drill weighs complete 239 pounds. The average power consumed about 1¾ H.P., and with this expenditure of power the drill will bore a hole of 1¼ inches diameter in hard rock at the rate of 2 inches per minute, taking out a core of ⅜ of an inch. The drill rod is rotated at the rate of 400 revolutions per minute without any load, and when drilling at full load the speed is practically the same.

The drill rod is geared by a single set of gears to an electric motor which revolves at 1,600 revolutions under conditions of full load. The motor has four poles, and the keeper joining the poles is in the shape of a surrounding cylindrical shell, which thoroughly protects all the parts of the motor and other parts of the machine.

Upon the drill rod is placed a rotary pump which supplies the drill with the necessary water.

In using the diamond drill the following points are of great importance:—

1. The speed should be uniform and automatically controlled very closely, so that removing the load quickly will not permit the drill to run away.
2. The drill should be extremely steady, as any material vibration transmitted by the drill rod to the diamond points is disastrous to them.
3. The drill should run at as high a rate of speed as is consistent with smooth drilling and a proper supply of water.

4. The drill should be as light and compact as is consistent with the requisite strength.

5. The drill should be capable of being readily and rapidily moved considerable distances, and put into operation again with the least loss of time.

Up to the present time diamond drills are operated by reciprocating engines, and the engine is fastened upon same frame as the drill rod to which it is geared by suitable gearing. The engine usually has two cylinders of the oscillating type to reduce the vibration as much as possible and eliminate the dead points. With these small engines it is practically impossible to automatically get the close regulation of speed which is desirable, and hence the speed is governed entirely by hand throttling, and the engines cannot be run at very high speed because of the vibration they would produce, and because of the rapid depreciation of such engines at high speed. It, therefore, becomes necessary to gear to the drill rod by gearing which is oftentimes objectionably larger and would become even more so if a higher speed upon the drill rod were attempted, as is desirable. The space occupied by the drilling machine is quite as large as the engine gears, and so forth, occupy much space. This is a great objection in cases of operation in tunnels, shafts, and so forth.

With the electric drill the motion is free from any jar, as there are no reciprocating parts, and the speed can be made absolutely constant under any condition of load up to the full load. The speed of the drill rod can be made anything desired up to several thousand revolutions per minute if desired, and under any conditions of speed above 1,600 per minute there would be no gears whatever. The weight of the electric diamond drill is for the same power much less than that of the steam diamond drill, and the space occupied is in a direct line with the hole and is extremely small in amount.

The drill can be operated from any existing electric light circuit, and the current for it can be supplied at two miles distance from the source of power by wires of size 10 B.W.G. having a diameter of about $\frac{1}{8}$th of an inch. The drill can be carried whenever a man can carry 35 pounds, which is the weight of the heaviest single piece, and hence can be set up and operated in the most inaccessible places.

It will be evident that for prospecting work, when a certain territory is to be explored, this drill is particularly adapted.

Starting from a convenient and economical source of power, we can, if desirable, lay our wires along the surface of the ground, and in a very few hours can be operating our drill miles off. We can then reel up our wire and lay it again in an exactly opposite direction, and again be in operation at perhaps five or ten miles off in the course of a few hours more. In laying the wire a couple of horses yoked abreast and carrying a reel is all that is necessary. For operating at a distance of one mile in any direction, the diameter of the wire necessary is but $\frac{1}{10}$th of an inch, and the total weight of the wire only 340 lbs.

The facility with which prospecting and also drilling in permanent works, such as mines, can be done with this drill will no doubt lead to its rapid and general use.

There is every reason to expect that with the electric diamond drill the speed of the rotation of the drill can be very greatly increased with consequent increase in the rate of drilling, which is of the greatest importance.

The Edison General Electric Company have a third kind of drill, which is a rotary high speed drill, having a solid steel bit, and this drill is used for drilling coal and similar comparatively soft materials and also for drilling metals, where it will have an extensive use in the construction of steel ships and bridges and similar works, where the drill has to be taken to the work rather than the reverse.

With the three drills which I have described, the Edison Company is now able to do any class of drilling desired, and these drills are likely to lay an important part in the future of mining engineering.

The electric mine locomotive and the hoists, pumps, ventilating fans, crushes, stamps, and so forth, operated by electricity are instances of the application of electricity to mining which have already proved themselves entirely successful. The under-cutting of

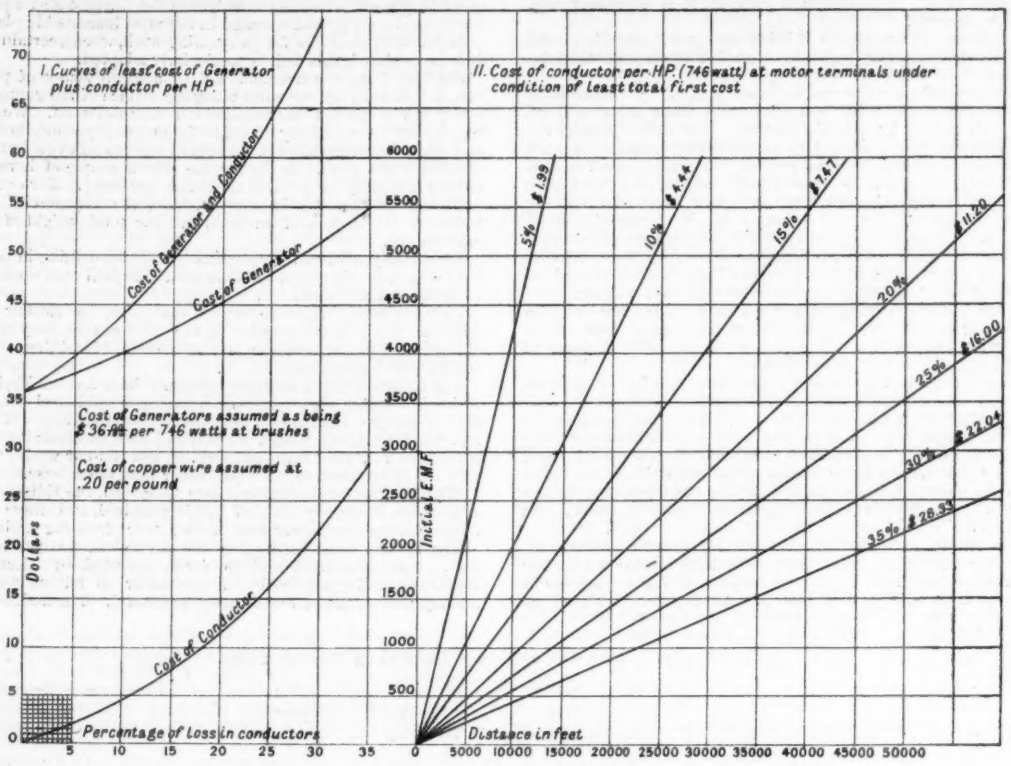
SHEET I.—RESUMÉ OF FORMULAS FOR DEVICES IN MULTIPLE ARC.

			SIZE.	WEIGHT.	COST.
Conductors as determined by losses therein.	Incandescent lamps.	Two wire system. — General cases ...	$M = \frac{T\,cp \times D \times 16{,}000}{\epsilon \times V \times C\,hp}$	$T = \frac{D^2 \times T\,cp}{V \times \epsilon \times C\,hp \times 1{,}000}$	$\$ = \frac{D^2 \times T\,cp \times L}{V \times \epsilon \times C\,hp \times 1{,}000}$
			$M = \frac{T\,cp \times D \times W \times 21{\cdot}5}{\epsilon \times V}$	$T = \frac{D^2 \times W \times T\,cp}{V \times \epsilon \times 746{,}000}$	$\$ = \frac{D^2 \times W \times T\,cp \times L}{V \times \epsilon \times 746{,}000}$
		For 100 volt lamps, 4·66 watts per cp ...	$M = \frac{T\,cp \times D}{V}$	$T = \frac{D^2 \times T\,cp}{V \times 16{,}000{,}000}$	$\$ = \frac{D^2 \times T\,cp \times L}{V \times 16{,}000{,}000}$
		For 110 volt 3·1 watt lamps	$M = \frac{T\,cp \times D \times 2}{3 \times V}$	$T = \frac{D^2 \times T\,cp}{V \times 24{,}000{,}000}$	$\$ = \frac{D^2 \times T\,cp \times L}{V \times 24{,}000{,}000}$
		Three wire system. — General cases	$\frac{1}{4}$ of corresponding 2 wire case.	$\frac{1}{3}$ of corresponding 2 wire case.	$\frac{1}{3}$ of corresponding 2 wire case.
		For 100 volt 4·66 watt lamps			
		For 110 volt 3·1 watt lamps			
	For any case		$M = \frac{C \times D \times 21{\cdot}5}{V}$	$T = \frac{C \times D^2}{V \times 746{,}000}$	$\$ = \frac{C \times D^2 \times L}{V \times 746{,}000}$
	For power at motor pulley		$M = \frac{D \times HP \times 1{,}600}{V \times \epsilon \times P}$	$T = \frac{D^2 \times HP}{V \times \epsilon \times 1{,}000 \times P}$	$\$ = \frac{D^2 \times HP \times L}{V \times \epsilon \times 1{,}000 \times P}$
	For minimum total initial cost of plant		... ...	... ...	$\frac{G \times E \times V}{(E - V)^2} = \frac{G \times p \times 100}{(100 - p)^2}$ = Dollars per H.P. delivered by conductor.
Generators for minimum total initial cost of plant			... ...	... ...	$\frac{100\,G}{100 - p}$ = Dollars per H.P. delivered by conductor.

Conductors as determined by safe heating.

Bare copper wire	15° C	$M = C^{\frac{1}{2}} \times 200$
	35° C	$M = C^{\frac{1}{2}} \times 170$
	45° C	$M = C^{\frac{1}{2}} \times 100$
Average insulated copper wire...	15° C	$M = C^{\frac{1}{2}} \times 150$
	35° C	$M = C^{\frac{1}{2}} \times 100$
Bare iron wire	45° C	$M = C^{\frac{1}{2}} \times 328$
Bare German silver wire ...	45° C	$M = C^{\frac{1}{2}} \times 608$

E = E.M.F. of generator in volts.
ϵ = E.M.F. of device in volts.
C = current in amperes
cp = candle-power of lamps at normal E.M.F.
$T\,cp$ = total candle-power of lamps.
$C\,hp$ = candle-power per electrical horse-power at normal E.M.F.
M = area of cross-section of wire in circular mils.
D = mean distance current is transmitted one way.
V = loss of E.M.F. in conductor (in volts).
$ = cost in dollars.
L = cost of copper per pound in cents.
W = watts per candle-power.
T = weight of wire in pounds.
P = efficiency of device.
p = percentage loss in conductors.
G = cost of generator per H.P. delivered by conductor.



coal by electricity is an important field in which the Edison Company has made great strides, the machine being of two entirely distinct types, which becomes necessary in order to properly comply with the conditions met with in practice in different mines.

The electric refining of metals, especially of copper, is an extremely interesting subject to the mining engineer. The Edison Company have established the majority of the plants of this nature in the United States; and I need only say that the results are highly economical and most satisfactory in every way.

The electrical transmission and conversion of energy at great distances is destined to come up in nearly every mining problem in the future. Mines are usually in a mountainous country and it is seldom that a water power cannot be found within a few miles of a mine. The mining engineer in the immediate future will develop this water power, convert its energy into electric energy, in which shape he will transmit it to the distant mine, when it will be again converted into the various forms of energy which he may have occasion to require.

Among the applications will be the following:—

1. The lighting of the mines and the buildings and grounds by arc and incandescent lamps.
2. The operation of any machinery in the mill, such as crushers, stamps, and so forth.
3. The operation of the drills.
4. The operation of the hoists.
5. The operation of the pumps.
6. The operation of an electric tramway in the mine.
7. The operation of ventilating fans.
8. The heating of the buildings when fuel is scarce.
9. The refining of copper and recovery of gold and silver in certain cases.
10. The concentration of magnetic ores in certain cases, such as iron, nickel, and so forth.

In order to give you a commercial idea of a plant such as is likely to be used in mining operations in the immediate future, I will suppose a case and give you an estimate of the first cost and operating expenses of such a plant. Let us suppose that we have a mine where we have to operate the following devices.

360 incandescent lamps of 16 C.P. each.
10 arc lights.
1 hoist requiring 30 H.P.
1 pump requiring 20 H.P.
6 percussion drills for drilling 1½ inch holes at the rate of 3 inches per minute.
2 rotary diamond drills, 1¼ holes, ⅜ core rate, 2 inches per minute.
1 mine locomotive, 10 H.P.
Milling machinery requiring 30 H.P.
Heating requiring 10 H.P.

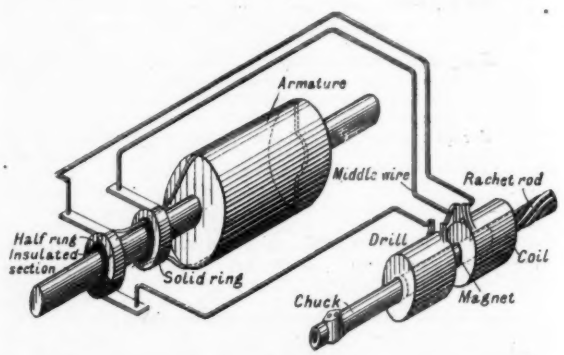
The total power required for the above will be 180 H.P. delivered over the main motors. Suppose that at a distance of three miles there is a good water power which can be developed and equipped with water wheels to produce 300 H P. by an expenditure of $15,000. In considering transmission of the power by electricity we must first determine what loss we shall sustain in transmission and then we must determine what electrical pressure we will operate with.

In designing such a plant there are certain fixed laws governing the conditions of highest economy and minimum first cost; and some years ago I investigated these questions and deduced formulæ expressing these laws.

These formulas are given in tabular form in the accompanying Sheet I. I have also expressed the laws governing the conditions of minimum initial cost graphically in Sheet II.

It may be interesting to note here in passing, a fact which you will observe by examining the formulæ given, namely: If we pay proper attention to the laws governing the highest efficiency and the least first cost, the cost of the conductors for the plant will depend solely upon the initial E.M.F. and the distance. Thus under practical conditions to-day, if we are to operate with 2,000 volts E.M.F. at a distance of 5 miles, the minimum first cost would be realised when we operate with a loss of 20 per cent. in conductors. The cost of copper (at 20 cents per bl.) for each horse-power delivered at the motor brushes under those conditions would be $7.47. This simple but invariable law, which is embodied in the formulæ given herewith, you will find of great assistance to you in considering questions of electrical transmission.

You will also notice that the formulæ show that, for any given



percentage of loss, the electrical pressure to be employed will vary directly with the distance. Thus, for 20 per cent. loss the cost of copper being $11.20 per horse-power delivered at motor brushes, the E.M.F necessary for tranamission of 16,000 feet will be 1,500 volts, at 32,000 feet we should use 3,000 volts, and at 8,000 feet 750 volts.

In order to secure the 160 H.P. necessary at our various devices in and about the mine, we must deliver 300 H.P. to our main motor in the form of electric energy in the conductor at the brushes of the motor. With 25 per cent. loss in conductors this will mean 266 H.P. at the generator brushes or 300 H.P. delivered by the water wheels.

For the sake of reliability and economy we will use two generators instead of one, each being of 133 H.P. At the mine there will be two main motors of 90 H.P. each, wound for 900 volts and 83 ampères, producing a total of 180 H.P., which will drive the drill generator of

17 H.P., and a generator of 250 volts and 300 ampères for operating the incandescent lamps, the arc lamps, the locomotive, the hoist, the pump, the diamond drills, and the heating. The main motors will also supply the milling machinery with the necessary 30 H.P.

By formulæ on Sheet I., we find that to transmit 180 H.P. 3 miles with 25 per cent. loss, and an initial pressure of 1,200 volts, there will be required a wire having a circular millage of 190,000 circular mils.; this is having a diameter of 436 thousandths of an inch, or a little less than half an inch.

We find that by other formulæ on Sheet I., that the copper will weigh 20,000 lbs., and will cost $4,000, which results check each other and prove the accuracy of the calculations.

We are now able to make an estimate for the total plant, as follows:—

Estimate of cost of plant for transmitting 180 H.P. a distance of 3 miles, with a loss of 25 per cent in conductors, the plant to comprise the apparatus as specified.

Developing original water power and installing water wheels of 300 H.P.	$15,000
2 generators, 100 k.w. each (1,200 v.—83 amp. each) at $36 per k.w.	7,200
2 motors, 75 k.w. each (900 v.—83 amp.) at $36 per k.w.	5,400
Copper, 32,000 feet, 4000 B.W.G.	4,000
1 6-drill generator	2,000
1 generator of 250 v., 300 amp., 75 k.w. at $36 ...	2,700
6 electric percussion drills	3,300
2 electric diamond drills	1,100
360 incandescent lamps and appliances	360
10 arc lamps	220
1 30-k.w. hoist	2,255
1 20-k.w. pump	1,595
1 10-k.w. locomotive	1,815
Heaters, 10 k.w.	600
Conductors for all secondary transmissions	1,000
Labour of installation	3,000
Poles	455
Freight, cartage, and sundry expenses	1,000
Total	$53,000

The operating expenses of such a plant will be those mainly due to the wages of men for each shift, one at the water-power and one at the mine.

A fair allowance for depreciation and repairs will be 5 per cent. per annum of the first cost.

The operating expenses will therefore be about as follows:—

One first operator	$900 per year.
One second operator	600 " "
Depreciation and repairs, 5 per cent. on $53,000	2,650
Sundry incidental expenses	250
	$4,400

The production of the same power by steam, when coal is $2.00 per ton, and labour such that an engineer's wages are $2.00 per day, would be not less than double this amount; and in many instances where water and coal suitable for the generation of steam are difficult to obtain, such a plant would represent a saving of its entire first cost every year.

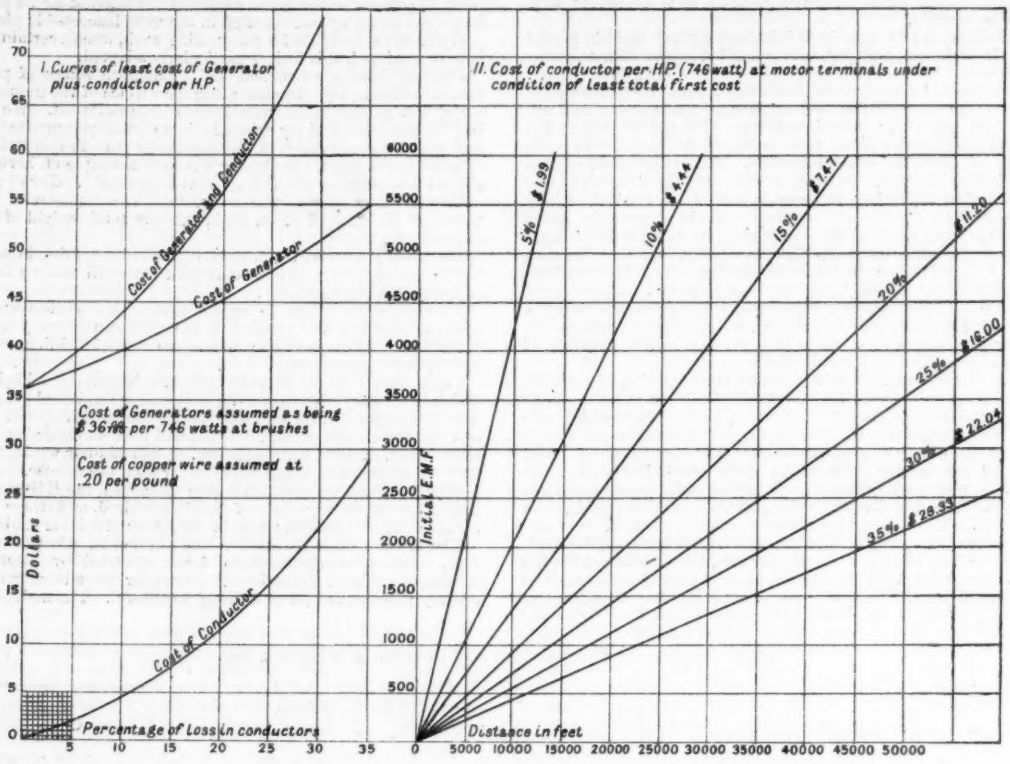
New York, *April 28th*, 1891.

ELECTRICITY IN THE PRODUCTION OF ALUMINIUM.

THE paper on "Electricity in the Production of Aluminium," read by A. S. Brown before the American Institute of Electrical Engineers, and published in our last issue, was followed by the following discussion:—

Prof. FRANCIS B. CROCKER: There are two points in connection with aluminium which I wish to consider particularly. The first relates to the properties and the second to the production of aluminium. I think that Mr. Brown spoke very truly in regard to the exaggerated ideas of the advantages of aluminum, but I do not think that he went quite far enough. The popular idea of aluminium is that all of the good properties of its alloys are attributed to aluminium itself. It is like one individual having all the good qualities of all his relatives attributed to him personally. This is, of course, an absurd fallacy. Nevertheless, it is one that is made in every newspaper article on the subject, and I am sorry to say that it is frequently made in technical journals. The most common mistake of the kind is to attribute to aluminium itself the tensile strength of aluminium bronze, which exceeds that of wrought iron, and is about as high as good specimens of steel. It is really one of the most tenacious metals known, but its composition is about nine parts of copper to one part of aluminium; yet its tensile strength is almost invariably attributed to pure aluminium, having a specific gravity of 2·6, which is only one-third that of iron. They take the low specific gravity of pure aluminium and the high tensile strength of aluminium bronze. As a matter of fact, the specific gravity of aluminium bronze is higher than that of iron. Therefore, we do not have lightness combined with high tensile strength. Turning again to aluminium itself, its tensile strength is about 26,000 lbs. per square inch; in other words, about one-third that of iron. This just balances the difference in specific gravity, but still leaves the advantage in favour of iron, because one-third of the volume has the same strength and the same weight as a rod of aluminium. Now, the same exaggeration is applied to its other qualifications; for example, its chemical properties. Aluminium bronze is remarkably free from tarnishing. A bright surface of aluminium bronze may be exposed to the atmosphere for several months and retain its polish. That property is attributed to aluminium itself. Aluminium, as Mr. Brown said, is not particularly liable to corrosion, but if it is subjected to salt water or alkaline water, or even ordinary moist air, it does tarnish or oxidise rapidly. Salt water is quite hurtful to it. Therefore, freedom from oxidation is another property that is wrongly attributed to it; and the objection to all this is that it gives a very wrong impression in regard to what would otherwise be a good and legitimate object of admiration. I am not prejudiced against the metal aluminium, and would be very glad to see it used extensively, but I do not think its extensive use will be hastened—in fact, I feel quite sure it will be retarded—by absurd exaggerations of its good qualities, because when people do come to use it they will be greatly disappointed. This common idea, for example, that it has 100,000 lbs. tensile strength per square inch, and about one-third the specific gravity of iron would lead any one into serious difficulties. There are certain things that seem to have a glamour about them—a word which Mr. Brown uses, and which expresses the fact perfectly. Storage batteries and aluminium seem to be particularly favoured by the public, and it has occurred to me that a combination of aluminium and storage battery—that is an aluminum storage battery—would be simply irresistible. Now, taking *seriatim* the actual properties of the metal, and considering them as mechanical, chemical and electrical, we have under the mechanical head a specific gravity of about 2·6, which is almost exactly one-third that of iron, and its tensile strength is 27,800 lbs., according to Mr. Brown, which is again almost exactly one-third of ordinary wrought iron. Therefore, iron and aluminium have equal strength, weight for weight; but iron has, as I have said, the great advantage of one-third of the bulk for the same strength and weight. Furthermore, any metal which "can be easily cut with a knife" is not particularly good for structural purposes as a metal. In my opinion it is too soft altogether. It is very much such a metal as zinc or tin. In fact, one can hardly tell the difference except by the weight, in filing or cutting it; and certainly tin or zinc are seldom used for structural purposes, and I do not think they would be, even if they were very much lighter than they are. Taking up the chemical properties—I have already alluded to the ease of oxidising, which, as I say, is not excessive, but still about equal to other metal, such as tin, zinc and iron. It is easily, in fact, eagerly, attacked by acids. It is not much affected by sulphur or sulphuretted hydrogen, which is a great advantage. It is very freely dissolved by alkalies, whereas most other common metals are not. In an ordinary alkaline solution, aluminium is dissolved, as most metals are, in acids, with the evolution of hydrogen. This is quite a serious disadvantage for a common metal, which is liable, for example, to have soap used upon it. We do not expect metals to be attacked by alkalies. As to the electrical properties—of course conductivity is about the only one. The electrical conductivity is about twice that of copper of equal weight, and is about half that of copper of equal volume. Where it is important to have a light wire, and the size is not to be considered, you can use an aluminium wire, because you get an advantage of 2 to 1 in weight. But when you consider size, for instance, a wire which has to be covered with insulating material that is expensive, then you would have a disadvantage. The figures happen to be very simple in all these cases. In regard to the manufacture of the metal, that, I think, is an electrical monopoly, for the simple reason that I do not think anything else can successfully compete with electricity in the production of a metal the chemical affinities of which are as high as those of aluminium. Aluminium has great chemical affinities, ranking about half way between the ordinary metals and metals like sodium and potassium. These chemical affinities exhibit themselves when it is attempted to separate aluminium from chlorine or oxygen, for example. The ordinary smelting process does not seem to have ever been successful in the reduction of aluminium. So far as I know, aluminium has never been successfully reduced as iron or other ordinary metals are reduced by merely smelting in a furnace with coal. The nearest approach to this is smelting in presence of carbon, but with a very high temperature obtained by the electric current, higher than can be obtained by smelting. Therefore, even if we employ the process of smelting, we still have to employ electricity. In any electrolytic reduction of the metal, of course, we have to employ electricity. Such a process seems to be a very simple and effective method, *i.e.*, the plain electrolysis of some compound of aluminium, the electrolyte being in a fused state between two electrodes. Now the fused state is necessary instead of the ordinary aqueous solution, because if you attempt to separate aluminium in an aqueous solution you will get hydrogen instead of aluminium. In other words, water is more easily decomposable than the aluminium compound. Then we have, as the only other likely substitute for these two electrical processes, the ordinary chemical method of reducing, by means of metallic sodium, some compound such as the chloride or double chloride of aluminium and sodium. But even then I think we had better make our sodium by electricity; so it would still be an electrical process. So far as I can see, and experience in the past few years seems to corroborate this view, electricity is the only commercial means of producing aluminium at the present price. In the old days, when the chemical process was used, aluminium was $12 or $15 a pound. Now it is about $1, and I doubt if any chemical process could compete on this basis. Therefore, the reduction of aluminium seems to belong to electrical science, and it is certainly a very interesting and important application of electricity, and is, I think, destined to be perfectly successful.

F. L. POPE: I have always felt a good deal of interest in aluminium as a metal ever since the time, many years ago, when the now vene-


I. Curves of least cost of Generator plus conductor per H.P.
II. Cost of conductor per H.P. (746 watt) at motor terminals under condition of least total first cost
Cost of Generator and Conductor
Cost of Generator
Cost of Generators assumed as being $36.00 per 746 watts at brushes
Cost of copper wire assumed at .20 per pound
Cost of Conductor
Dollars
Initial E.M.F.
Percentage of Loss in conductors
Distance in feet
5% $1.99
10% $4.44
15% $7.47
20% $11.20
25% $16.00
30% $22.04
35% $29.33

coal by electricity is an important field in which the Edison Company has made great strides, the machine being of two entirely distinct types, which becomes necessary in order to properly comply with the conditions met with in practice in different mines.

The electric refining of metals, especially of copper, is an extremely interesting subject to the mining engineer. The Edison Company have established the majority of the plants of this nature in the United States; and I need only say that the results are highly economical and most satisfactory in every way.

The electrical transmission and conversion of energy at great distances is destined to come up in nearly every mining problem in the future. Mines are usually in a mountainous country and it is seldom that a water power cannot be found within a few miles of a mine. The mining engineer in the immediate future will develop this water power, convert its energy into electric energy, in which shape he will transmit it to the distant mine, when it will be again converted into the various forms of energy which he may have occasion to require.

Among the applications will be the following:—

1. The lighting of the mines and the buildings and grounds by arc and incandescent lamps.
2. The operation of any machinery in the mill, such as crushers, stamps, and so forth.
3. The operation of the drills.
4. The operation of the hoists.
5. The operation of the pumps.
6. The operation of an electric tramway in the mine.
7. The operation of ventilating fans.
8. The heating of the buildings when fuel is scarce.
9. The refining of copper and recovery of gold and silver in certain cases.
10. The concentration of magnetic ores in certain cases, such as iron, nickel, and so forth.

In order to give you a commercial idea of a plant such as is likely to be used in mining operations in the immediate future, I will suppose a case and give you an estimate of the first cost and operating expenses of such a plant. Let us suppose that we have a mine where we have to operate the following devices.

360 incandescent lamps of 16 C.P. each.
10 arc lights.
1 hoist requiring 30 H.P.
1 pump requiring 20 H.P.
6 percussion drills for drilling 1½ inch holes at the rate of 3 inches per minute.
2 rotary diamond drills, 1¼ holes, ⅝ core rate, 2 inches per minute.
1 mine locomotive, 10 H.P.
Milling machinery requiring 30 H.P.
Heating requiring 10 H.P.

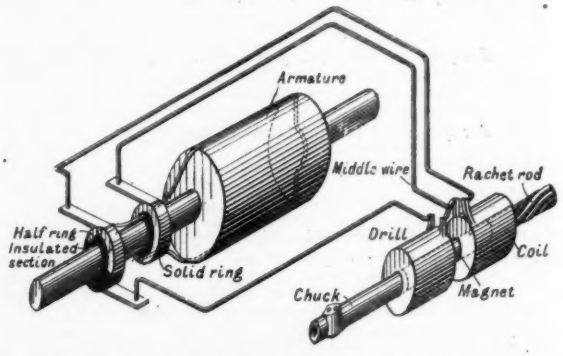
The total power required for the above will be 180 H.P. delivered over the main motors. Suppose that at a distance of three miles there is a good water power which can be developed and equipped with water wheels to produce 300 H.P. by an expenditure of $15,000. In considering transmission of the power by electricity we must first determine what loss we shall sustain in transmission and then we must determine what electrical pressure we will operate with.

In designing such a plant there are certain fixed laws governing the conditions of highest economy and minimum first cost; and some years ago I investigated these questions and deduced formulæ expressing these laws.

These formulas are given in tabular form in the accompanying Sheet I. I have also expressed the laws governing the conditions of minimum initial cost graphically in Sheet II.

It may be interesting to note here in passing, a fact which you will observe by examining the formulæ given, namely: If we pay proper attention to the laws governing the highest efficiency and the least first cost, the cost of the conductors for the plant will depend solely upon the initial E.M.F. and the distance. Thus under practical conditions to-day, if we are to operate with 2,000 volts E.M.F. at a distance of 5 miles, the minimum first cost would be realised when we operate with a loss of 20 per cent. in conductors. The cost of copper (at 20 cents per bl.) for each horse-power delivered at the motor brushes under those conditions would be $7.47. This simple but invariable law, which is embodied in the formulæ given herewith, you will find of great assistance to you in considering questions of electrical transmission.

You will also notice that the formulæ show that, for any given



percentage of loss, the electrical pressure to be employed will vary directly with the distance. Thus, for 20 per cent. loss the cost of copper being $11.20 per horse-power delivered at motor brushes, the E.M.F necessary for transmission of 16,000 feet will be 1,500 volts, at 32,000 feet we should use 3,000 volts, and at 8,000 feet 750 volts.

In order to secure the 160 H.P. necessary at our various devices in and about the mine, we must deliver 300 H.P. to our main motor in the form of electric energy in the conductor at the brushes of the motor. With 25 per cent. loss in conductors this will mean 266 H.P. at the generator brushes or 300 H.P. delivered by the water wheels.

For the sake of reliability and economy we will use two generators instead of one, each being of 133 H.P. At the mine there will be two main motors of 90 H.P. each, wound for 900 volts and 83 ampères, producing a total of 180 H.P., which will drive the drill generator of

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Heaters, 10 k.w.	600
Conductors for all secondary transmissions	1,000
Labour of installation	3,000
Poles	455
Freight, cartage, and sundry expenses	1,000
Total	$53,000

The operating expenses of such a plant will be those mainly due to the wages of men for each shift, one at the water-power and one at the mine.

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It is really one of the most tenacious metals known, but its composition is about nine parts of copper to one part of aluminium; yet its tensile strength is almost invariably attributed to pure aluminium, having a specific gravity of 2·6, which is only one-third that of iron. They take the low specific gravity of pure aluminium and the high tensile strength of aluminium bronze. As a matter of fact, the specific gravity of aluminium bronze is higher than that of iron. Therefore, we do not have lightness combined with high tensile strength. Turning again to aluminium itself, its tensile strength is about 26,000 lbs. per square inch; in other words, about one-third that of iron. This just balances the difference in specific gravity, but still leaves the advantage in favour of iron, because one-third of the volume has the same strength and the same weight as a rod of aluminium. Now, the same exaggeration is applied to its other qualifications; for example, its chemical properties. 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F. L. POPE: I have always felt a good deal of interest in aluminium as a metal ever since the time, many years ago, when the now vene-

rable Moses G. Farmer said to me: "There is seven dollars' worth of aluminium in every brick, if we could only get it out, but," he continued, reflectively, "I suppose if we should finally get it out, it would no longer be worth seven dollars." So it was not without gratification that a little over two years ago I accepted a commission in behalf of the parties who subsequently established the plant at Boonton, of which Mr. Brown has told us this evening, to visit the works where the Heroult process was then being carried on at the Falls of the Rhine in Switzerland, and make a careful investigation of it. One thing that struck me very forcibly was the small amount of manual labour required in the works in proportion to the value of the product. They were turning out at the Rhine Falls a good many hundred pounds a day of aluminium bronze, and employed only six men, five of whom were ordinary day labourers. I was also particularly impressed with the admirable performance of the dynamos used in Switzerland, which are precisely the same as the one at Boonton, which Mr. Brown described. There were two of them coupled together, and to a vertical turbine, and rated at 150 horse-power each —a very moderate rating I should say. I saw the ammeter, on one occasion when I was watching it, indicate 27,000 ampères. The current heated the loop of the conductor which surrounded the ammeter, which was a copper bar 3½ inches square, yet very little sparking was perceptible at the brushes of the dynamo. The machine gave a sort of a grunt when this great load was thrown on, but that was about all the effect that was observable.

ALBERT STETSON: The trouble with aluminium is not in the making of it, but in the handling of the metal after it is made. There are only very few people in all the world who know how to handle the pure metal and cast it, and even those people, with all their experience, very often get poor castings, and so their work becomes very expensive. Good work can be done by teaching the manufacturers of the country what to do with the material after they get it.

THE RELATIVE COST AND ECONOMY OF HIGH AND LOW PRESSURE CENTRAL STATIONS.

BY G. L. ADDENBROOKE.

THE discussion at the last meeting of the Institute of Electrical Engineers, on Mr. Preece's paper, roused again in an acute form the old question of the rival merits of low pressure *versus* high pressure, or A. T. distribution.

At the previous meeting, Mr. Crompton, as his contribution to the discussion, had sent in a paper based on two tables of figures, which apparently showed that a three-wire system of mains, for a low pressure supply, was practically as cheap to lay down and maintain for distances of 2,400 yards from the generating station, as a two-wire high pressure system, and that as a natural corollary, it was cheaper for anything under these distances.

In the excellent paper which he lately read before the Civil Engineers, Mr. Crompton stated that the coal expenditure per unit, sold to customers, was last year about 9½ lbs. in his low pressure station at Kensington, whereas that in a transformer station, with transformers in each house, under similar circumstances, would not be much under 16 lbs.

These two statements, added to the moderate and able speech of Sir William Thomson, in the course of the discussion, in which he rather leaned towards a system of low pressure distribution, with a number of central stations, together constitute what, in the eyes of outsiders at any rate, must be a serious impugnment of the advantages of high tension at all.

At a time, then, when the question is being debated as to what system of supply shall be adopted in several large towns, and when considerable financial issues are directly involved, it is clearly of importance that such statements as these should not go forth to the world without the grounds on which they are based being stated, and without their bearings on the whole question being well defined.

Now, Mr. Crompton's figures on the relative cost of low pressure and high pressure mains are, when carefully examined, evidently based on some misconception. Everyone is liable to make slips and clerical errors from time to time, and no one would wish to take an unreasonable advantage under such circumstances, but as in this case an elaborate argument is founded on figures which cannot be controverted without going through them, it is only fair that it should be refuted, and that the refutation should enjoy as much publicity as the original statements.

An inspection of Mr. Crompton's tables shows that, however correct he may be in his low tension calculations, he is at sea when he comes to deal with high tension.

In the first place, he has put down the cost of excavation and extra width culvert and pipes as the same for both high and low pressure feeders, whereas it is clear that for high pressure a smaller culvert or pipe would suffice than for low pressure.

In the next place, his estimate of the cost of the high pressure cable is entirely misleading. A cable to transmit 100 kilowatts at 2,000 volts pressure, with a *maximum* loss of 10 per cent., would have a resistance of 4 ohms, and the size of conductor which would give this resistance for a double length of 2,400 yards would be as nearly as possible 7/14., the cost of which, with highest quality of rubber insulation, would be about £440 laid, instead of £1,300, as given by Mr. Crompton.

Lastly, the figure of £440 for transformers for 100 kilowatts and fixing is rather excessive, as the cost of making large transformers is relatively much less than that of small ones.

If, then, these items are corrected and totalled up, we shall obtain a cost for the A. T. feeder, 2,400 yards long, of about £1,420, or exactly half of that given by Mr. Crompton for his low-tension feeder on the three-wire system.

This great difference, of course, entirely upsets the comparisons as to capital cost and to cost of up-keep, and therefore the only points in the statements as to up-keep which need remark are the percentages which have been allowed on the various items. Why Mr. Crompton should consider the cost of up-keep of a transformer pit as 2½ per cent., and that of a culvert such as he constructs as 1 per cent., is not quite clear. Again, why should the cost of up-keep on transformers and apparatus be put at 10 per cent.? In estimating the cost of up-keep of dynamos, 5 per cent. is considered a fair amount to allow, and therefore it is not apparent why anything more should be allowed on a transformer which has no moving parts, and on switches which are only used twice a day.

Taking the capital cost of the high tension feeder as half that of the low tension, the cost of maintenance will also be found about half, but as pointed out in the debate on Mr. Crompton's paper, the whole position he has taken up is not a practical one, because no one who had had practical experience of transformer systems, would lay down feeders in which 10 per cent. of the average energy transmitted would be lost in a distance of 2,400 yards. Practically the loss under these circumstances should never be more than a maximum of 2½ per cent., or one quarter of that allowed by Mr. Crompton. In such a case the cost of cable if insulated with rubber of the highest class would be about that shown by Mr. Crompton, and therefore his figures, with slight modification, might be accepted; but then in this case there is a saving of over 7½ per cent. in the energy transmitted by the high tension cable over the low, and this saving I estimate at over £165 a year at a rate 6d. per Board of Trade unit, on the basis adopted by Mr. Crompton.

Again, as Mr. Kapp pointed out, Mr. Crompton has simply dealt with the cost of the mains, he has said nothing about the fact that he would probably have nearly 20 per cent. loss at full load, and that he would have, therefore, to provide at least 20 per cent. more generating capacity at his central station than is required on the high tension system, and this means not only plant but wages also.

Coming, however, to the general question, and taking the results as given us by Mr. Crompton in the excellent and valuable paper lately read by him before the Institute of Civil Engineers, it is now possible to make, in a moderate space, a pretty complete comparison of the relative capital cost, cost of up-keep, and economy of distribution of stations on the two principles.

In the first place, as regards the central station, if we use high speed engines coupled direct to the dynamos, we shall have identically the same steam and electric plant in each case, except that the dynamos are continuous current in one case and alternating in the other, and that the latter are separately excited. Unit for unit the two plants will occupy about the same space, will require the same size and class of building, and will cost as nearly as possible the same price. The alternator will possibly be rather more expensive than the continuous current machines, but this can be balanced against the extra cost of omnibus bars, switches and regulators in the low over the high pressure system, so that as far as the station goes the two systems will cost almost

exactly the same, with the proviso as mentioned above, viz., that to meet the great loss on the mains at full load with the low pressure system, either 20 per cent. more plant or the equivalent in accumulators must be provided, and this is an extra on the cost of the low over the high pressure system.

We now come to the distribution portion of the system.

From what has already been said, it is clear that a feeder, 2,400 yards long, can be put down on either system for the same money, including culverts, cables, and in the case of the alternating feeder, transformer pit and transformers; but whereas in the low pressure system, 10 per cent. of the energy transmitted through the feeder will be lost; with the high pressure main less than 2½ per cent. will be lost; there will be some loss in the transformers in the high pressure system, but if a small transformer is used during the day, the whole loss will not more than equal that on the low pressure system.

Since the cost of a low tension network, spreading from the feeding points, in both cases will be similar, we therefore have the facts that, both in first cost and in economy of distribution, the high pressure distribution system equals the low for distances of 2,400 yards from the centre.

Again, Mr. Preece, in his paper, drew attention to the fact that in the excellent station at Rome, for which Messrs. Zipernowski, Deri and Blathy, of Messrs. Ganz & Co., are responsible, which is worked on the principle of sub-transformer stations, the coal expenditure per unit sold to customers is about 10 lbs., which compares with Mr. Crompton's 9·5 lbs. per unit at Kensington, and, indeed, it must be evident that the economy of generation of the two systems on the basis taken must be similar, since alternating dynamos have about the same efficiency as continuous.

It is true that in a transformer station with transformers in each house the expenditure of coal per unit sold to customers will not be much under 16 lbs.; but as to this, it must be remembered that this is only about 1½d. per unit for coal, as against 1d. for a low-pressure system, or a difference of ½d. per unit, say, 6½ per cent., on the receipts. This extra expenditure, however, does not need extra boilers or much extra labour, as it occurs chiefly during off hours, when the load is light and when the men who must be employed to fire are not busy, the loss being little more at full load than when next to no light is being used.

Against this extra cost of coal for generators can easily be put the additional plant or accumulators, and the additional cost of labour for meeting the excessive loss at full load which occurs with a low-pressure supply, consequently even the ordinary method of working a transformer system with transformers in each house compares favourably in ultimate economy with a low tension system, while if transformer sub-stations are employed wherever there is much lighting in a moderate area the full economy of generation of the low pressure system is secured, together with all the power of extension of the high pressure system, and at a reduced capital cost.

From what has been said, therefore, it is abundantly manifest that even if high pressure stations had to be situated in the centres of towns, and to be multiplied in number as low pressure stations have, their ultimate economy would still compare favourably with the low pressure system of supply, and therefore we may at least postulate to the credit of high tension, all the saving in ground rent, buildings and convenience which is effected by placing a central station in the suburbs, besides the economy in labour and in administration which consolidation of all the work on one spot necessarily effects.

FURTHER RESEARCHES ON THE ELECTRICAL CONDUCTIVITY OF THE HEATED VAPOURS OF SALTS.

In our issue for February 13th, page 202, we gave a short account of some experiments by S. Arrhenius upon the electrical conductivity of salts in the flame of a Bunsen gas burner. In this research, certain relations were observed to exist between the conductivity of the salts and the concentration of the solutions. It was also noticed that whereas a great many of the metallic salts practically have no conductivity under these conditions, those of the alkaline earths appear to conduct electrolytically, while those of the alkalies conduct equally well. The general conclusion arrived at was that when the vapours of salts are caused to pass through the gas flame from a Bunsen burner, they behave like a feebly dissociated electrolyte, the chief point of difference being that Ohm's law does not hold good when the electromotive force has a large value.

Experiments upon this interesting field of research have during the past few months been continued by Arrhenius, and there is an important paper in the *Annalen der Physik und Chemie* [series [2], No. xlvii., p. 18], in which the observations made are more fully discussed than in the previous paper, and a number of newly discovered facts are enlarged upon.

As in the preliminary investigation, the salts were dissolved in water to a known degree of concentration, and the solutions were introduced through the air-holes of the Bunsen burner in the form of a fine spray; the means of observing any alteration in the resistance between two platinum plate electrodes placed in the flame, caused by the introduction of this saline spray, were the same as before.

When the salts of the alkali metals were "sprayed" into the flame, it was observed that in each case the salt possessed a certain conductivity which was quite independent of the nature of the negative radicle, and that the salts of any one of these metals possessed the same conducting power for equal degrees of dilution. This is particularly true when the concentration is very low; when the concentration is high, more difference is noticeable, the individuality of the salt is asserted, and this is especially marked in the case of the salts of sodium.

It was necessary in these experiments to know the proportional amount of saline vapour present in the hot gases which constitute the flame; in other words, what Arrhenius calls the "dilution" of the saline vapour, and this was generally carefully estimated.

The difference in the haloid salts of the metals is one of degree, and it was observed that their order of conductivity may be arranged, thus

i. ... ... Iodides,
ii. ... ... Bromides,
iii. ... ... Chlorides,

the iodides being the most conducting. The fluorides were not examined.

As a general rule, the conductivity of the salts varies directly with the atomic weight of the metal: the greater the atomic weight the greater the conductivity. Exceptions to the rule that the conductivity changes with the dilution, so that it is always proportional to the square root of the concentration, were observed in cases where the dilution was great; in such cases the increase in conductivity is somewhat greater. When the dilution was carried to an extreme degree the increase in conductivity is somewhat less than that calculated from the square root of the concentration.

In the case of the salts of the alkali metals the hot gases of the flame immediately take the conductivity characteristic of the salt introduced, but this is not observed when solutions of salts of the alkaline earths are "sprayed" into the flame: here the conductivity of the flame increases slowly until it reaches a maximum.

It is curious to notice that the effect of the salt on the flame does not immediately disappear as soon as the supply of saline spray is cut off: its influence seems to remain for *many hours*, and can, in fact, only be finally removed by washing the platinum electrodes in hydrochloric acid. The explanation of this offered by Arrhenius is the following: The platinum plates which serve as electrodes in the flame become coated with the oxide or the sulphide of the metal, and the presence of these substances as foreign particles in the flame serves to bring about a conductivity perfectly independent of that of the salts themselves. For this reason the observations in the case of the alkali metals are different; it is found, however, that a maximum conductivity is reached most rapidly the higher the atomic weight of the metal; the rate also depends directly upon the concentration of the salt; the stronger the salt the more rapidly is the maximum reached. The conductivity also appears to increase with the atomic weight.

Arrhenius has placed the salts of a very large number of

metals under examination (his paper occupies nearly sixty pages of the *Annalen*), but of all the salts examined, only silver nitrate and lead nitrate were found to have any very appreciable conductivity when their solutions were "sprayed" into the Bunsen gas flame.

One interesting and perhaps somewhat unexpected result was that obtained with mixtures of potassium and sodium sulphates and chlorides; the mixed salts behave just as electrolytes do which possess an ion in common. Hence it is possible to calculate within the limits of experimental error the conductivities of such mixtures from those of the salts composing them in accordance with the principles laid down by Arrhenius in a paper published in the *Zeit. Physikal. Chem.*, No. V., p. 1, on the conditions of equilibrium between electrolytes.

From the observations which Arrhenius has made he concludes that the conductivity of saline vapours in the heated gases in the flame of a Bunsen burner may be of two kinds, namely :—

1. The conductivity of the solid particles which may be evolved during the decomposition of the salt.

2. The conductivity due to the salt itself; this is of an electrolytic nature.

The conductivity takes place in accordance with Ohm's law, where the electromotive force is not greater than 0·2 volt. But where the electromotive force is greater than 0·2 volt, Ohm's law no longer holds.

It was noticed that in the case of the metals of the alkalies, all the salts possess the same conductivity. Arrhenius explains this fact by assuming that at 1,200° Centigrade, which is the temperature of the Bunsen gas-flame, the saline matters undergo dissociation. The flame would necessarily contain a considerable quantity of aqueous vapour, and hence, in the presence of this, the metals of the salts would be converted into hydroxides, and the acids would be set free. Now, since these acids have no conductivity, the hydroxides would alone, and in all cases, be active; therefore the conductivity of the salts of any given alkali metal would always be the same, namely, that of the hydroxide of the metal.

Finally, Arrhenius discusses the change in conductivity which follows any variation in the concentration of the salt. He seems to regard the conductivity as electrolytic, and hence he considers that the laws which have already been established for aqueous solutions may be applied in the case of heated saline vapours. The agreement between the theoretical deductions and the experimental results is claimed by Arrhenius to establish the general accuracy of his assumption, and also as going in favour of those laws of gases which have been deduced from the study of dilute solutions.

SOME RECENT RESEARCHES ON THE ELECTROMOTIVE FORCE OF GALVANIC ELEMENTS.

A SERIES of important experiments has recently been carried out by two German physicists, A. Oberbeck and J. Edler, with "non-reversible" galvanic elements. Amalgams of zinc, cadmium, tin and lead, were prepared by the electrolytic method, and as regards their polarisation they were found to behave like the metals themselves. These amalgams, and also an amalgam of bismuth not prepared electrolytically, were immersed in different saline solutions, and their electromotive force was measured in each case against mercury by using a mirror galvanometer and the "compensation" method.

Amongst the solutions used were the sulphates, chlorides, bromides and iodides, and it appears from the results obtained in an extended series of observations that, besides depending upon the two metals which form the electrodes, the electromotive force is also dependent upon the negative component of the saline solutions in which these electrodes are immersed. No influence is exerted by the metal of the salt, except when it is the same as one of the electrodes as

Lead amalgam | Lead sulphate | Mercury

and in this case the effect is to cause a diminution in the electromotive force.

It was noticed by Messrs. Oberbeck and Edler that when the metals are arranged according to the magnitude of the electromotive force, they always follow each other in the same order, no matter what the salt or acid solution may be. This order is for the metals examined during this investigation as follows :—

(1) Zinc. (2) Cadmium. (3) Tin. (4) Lead. (5) Bismuth.	Order constant when solution varies.

It is noteworthy that when the amalgams of lead and tin were investigated in alkaline solution the electromotive force showed an abnormally high value.

In the original paper there is a short account of the previous investigations that have been made on the electromotive force of voltaic combinations, and in summing up the results of the present research a certain connection existing between the electromotive force and the heat formation of certain salt solutions as determined by Thomsen is pointed out.

A NEW APPLICATION OF ELECTRICITY IN THE PURIFICATION OF WATER.

Two new methods of softening water for industrial purposes have been recently proposed by M. Labrowski. One of these involves purely chemical reactions, and need not be noticed here; the other introduces an ingenious application of electricity.

Hydrated oxide of lead is placed in a filter press which is traversed by the water to be purified, and this produces an effluent showing only one or, at most, two degrees of hardness. In this way all the carbonates, sulphates, and chlorides are precipitated.

Now, in order to work this process economically, it is necessary to produce the hydrated oxide of lead cheaply, and the following method has been devised by Villon for this purpose.

Sodium nitrate is dissolved in water, and the solution is placed in a vat divided into two compartments by a diaphragm; lead electrodes of large surface are placed in the solution, and the current from a dynamo then passed through. The sodium nitrate is decomposed, caustic soda being formed in the negative compartment and nitric acid at the positive pole, from which it dissolves a certain quantity of lead forming lead nitrate.

After the current has been passing through the liquid for a certain time, the solutions that result from the various decompositions are run from the two compartments into a second vat, and then mixed mechanically by means of an agitator. The soda precipitates hydrated oxide of lead, and itself forms sodium nitrate; the liquid is then filtered, and the sodium nitrate solution which runs through the filter is again subjected to electrolysis.

When the hydrated oxide of lead has been in use for some time it is then replaced by fresh oxide; the proper time for replacing the contents of the filter press is indicated by the degree of hardness of the water.

OPERATING SUB-STATIONS BY THE MOTOR-DYNAMO SYSTEM IN BROOKLYN.*

BY W. G. BARSTOW.

THE Edison Electric Illuminating Company of Brooklyn, during the fall of 1890, resolved to extend their territory for furnishing low tension light and power, by the erection of a second district station. After a careful consideration of the matter, it was deemed best to supply this new territory from their present first district station until a sufficient load was accumulated to warrant the expenditure necessary for the erection and maintenance of the second district station. For this purpose a large feeder, consisting of copper conductors of 1,000,000 circ. mils each, was laid underground to a point two miles distant from the present first district

* New York *Electrical Engineer*.

station. From this point sub-feeders were laid, and these in turn were heavily bridged by the net-work of mains. A standard feeder is selected from one of these sub-feeders, and at the extremity of this the voltage is kept at a constant pressure. As the load increases, the voltage is necessarily raised at the station end of the large feeder so as to preserve the voltage at the extremity of the sub-feeder. The efficiency of this system of low tension long distance transmission depends on the cost of the loss in the main feeder compared with the increased operating expenses of a second district station. When the cost of the loss (in watts) in this transmission equals the operating expenses of a second district plant, then this plant will be erected and will be run until the cost of operating exceeds the loss in transmitting from the first district station. It has been theoretically calculated (and since proved by practical results) that 1,000 ampères can be transmitted before the starting of the new station is necessary.

After the plans of underground feeders had been fully developed, attention was turned to the mode of generating this transmitted current. As the first district station is supplied with auxiliary buses, it was a simple matter to operate one or more station units (300 H.P. Ball compound non-condensing engine and two No. 32 Edison generators), on an auxiliary bus and connect the main feeder to it; but when it was taken into consideration that the new district load at certain portions of the day would not be more than 50 H.P., the efficiency of a large station unit became evident.

After due consideration it was decided to operate the generators supplying this feeder by a motor, which, in turn, would be supplied by the bus of the first district station. A 50 H.P. C. & C. motor with pulley at both ends of the armature shaft was installed and connected to the station bus, and from this were belted two No. 6 Edison compound generators. This plant shows an average commercial efficiency of over 75 per cent., while the efficiency of the large station, by reason of the extra motor load, is increased over 10 per cent. The advantage of this arrangement can be better appreciated when it is known that, on a station unit, the loss of power due to engine friction and belting on an average load of 224·9 H.P. (at the engine) is 38·5 H.P. Should the load on the engine average 50 H.P., the low efficiency of the unit can easily be appreciated. The question of installing a smaller engine was contemplated, but on close investigation the idea was abandoned in favour of the motor.

The mission of this motor-dynamo plant is nothing more than to transform the bus pressure of the first district station to a variable pressure required at the station end of the large feeder in order to maintain a constant pressure at the standard sub-feeder extremity. Should the pressure on the station end of this main feeder equal the bus pressure of the first district (on account of light load), the little motor-dynamo plant is shut down, and the feeder thrown on to the station bus. Should the load exceed the capacity of the little plant, it is then of such proportion as to render the larger station unit efficient. One favourable point in this transmission system is that no extra help is required, the men usually employed in operating the large station easily taking care of this slight increase.

Work was commenced on this system on or about October 15th, 1890, and before December 1st a system of mains and feeders (capacity 2,000 16-C.P. lamps) was supplying 500 16-C.P. lamps, 26 Ward low tension arc lamps, and 10 H.P. in motors. On April 1st, 1891, there were connected to this system, 2,000 16-C.P. lamps, 58 arc lamps, and 65 H.P. in motors. The little motor-dynamo plant furnishes current from 2 a.m. to 6 p.m., a station unit from 6 p.m. to 11 p.m., and the station bus from 11 p.m. to 2 a.m. Until the evening load was sufficient to be carried on a station unit, this motor-dynamo plant was in operation 21 hours per day and seven days per week.

When the new second district station is started, the main feeder will serve as a tie line between the two stations, so that either can be shut down during a light load to save operating expenses.

Among the many consumers in this district there is one who is operating one motor of 25 H.P. and two of 10 H.P., which are supplied with current at a point two and three-quarter miles distant from the little transmitting plant.

PAPER INSULATION FOR ELECTRIC LIGHT AND TELEPHONE LEADS.

ONE of the most important strides, says a New York Exchange, in the matter of insulation of cables for powerful electric light currents has been made within the last three or four years. Many materials have been tried, and found more or less wanting. The mechanical and electrical requirements of a 10,000-volt conductor of the present day are very exacting. The cable must be light and flexible; it must be strong enough to withstand the strain and wear and tear of reeling and unreeling and hauling through crowded conduits without exposing the insulation to damage. The insulation must be high at normal temperatures, so as not to fall too low when exposed to excessive heat, and it must further be able to retain its power of preventing a break-down or blow out even when the insulation has fallen very low from such exposure.

The Norwich Insulated Wire Company, of New York, claim that these requirements are met absolutely in their cables, in which paper is employed as the insulator. This company are working night and day to meet the demand for their cables, which is chiefly for No. 6 B & S wire leaded cable, outer diameter $\frac{8}{8}$ths inch. Some 25 miles of this cable are now being laid in New York alone, and in Chicago over 30 miles have been laid, whilst orders have been filled for England, France and Germany, including a very large sectioned 10,000-volt concentric Ferranti cable. The company has yet to receive its first complaint of a breakdown, although their cables have been laid and jointed by the lighting companies' regular cable men, who use their own way of jointing, the company finding it unnecessary to recommend any special method.

The process of manufacture is very simple, but one requiring great care and watchfulness. The paper is made expressly for the company by one of the largest mills in the country, and requires storing like wood to become seasoned for use. It is made in rolls of from half a mile to five miles in length, and weighing from 20 to 90 lbs. per ream. The first process is to cut it up in strips by means of circular shears. These strips are mounted on mandrils made to fit the covering machines, which, revolving at from 60 to 500 turns per minute, according to the size of the conductor, lay the paper on it in overlapping spirals.

As with every spiral laid on, the cable is passed through closely fitting dies, the result is a very hard, dense, compact and flexible covering, very difficult to damage or abrade, and at the same time one of exceedingly uniform diameter. The layers of paper are laid on with their spirals alternately in opposite directions.

After covering to the requisite thickness, the cable is wound on open iron reels and placed in drying ovens, where it is exposed to a temperature of about 250° F., until all the moisture is thoroughly expelled. Then, while still hot, it is submerged in compound, which is maintained by steam coils at a heat of some 270° to 280° F., for a length of time depending on the thickness of the insulation or other electrical requirements. The nature of this compound is a close secret. It is then passed directly from the tanks through the hydraulic press which puts on the lead covering. The machinery by means of which the lead is laid on the cable in one continuous length, was designed and constructed under the patents of Mr. J. Draper Bishop, the electrical engineer of the company.

The cables are then tested, when necessary, at a potential of 2,500 volts for insulation, as well as for conductivity and capacity.

The insulation is always high, exceeding on an average 2,000 megohms at 75° F.

Some of the performances of these cables are remarkable. Lengths of 1,000 feet were submitted to one of the largest electric light companies for the purpose of being tested to "break down." They successfully resisted a strain of nearly ten thousand volts, and were finally left intact. The cable was then placed in *boiling water* and kept submerged for *forty-eight hours*. While still in the tank it resisted a potential of nearly eight thousand volts before failing.

One most important advantage possessed by these cables is that, no matter how rough a treatment the cable may be submitted to, even to destroying the lead and rupturing the insulation, the conductor will always remain absolutely concentric. The insulation is uniform throughout every inch

of its length and cannot by any accident of manufacture or subsequent treatment become thinner on one side than another, or, in other words, eccentric.

The Norwich Insulated Wire Co. has also made a considerable quantity of telephone cables, over 5,000 miles of conductor being laid in New York alone. The capacity of these cables, when made to conference standard specification, has been reduced during the past year from ·22 microfarad to below ·08 microfarad per mile.

The company has lately increased its plant to a capacity of a mile a day of such cable. Its latest undertaking is the manufacture of paper insulated leads for incandescent house and office wiring.

AN EXPERIMENTAL ANALOGUE FOR DIRECTION OF INDUCED CURRENTS.*

BY L. F. RONDINELLA, M.E.,
Prof. of Drawing, Central Manual Training School.

THE striking analogies which exist between current electricity and magnetism, form an important aid in acquiring a clear understanding of the fundamental principles of modern electrical science. For example, an electric current is assumed to pass through a generator from its south to its north pole, and from thence through an external circuit back to the south pole again. So, also, are magnetic "currents," or lines of force assumed to pass through and outside of a magnet.

In an induced electric current lines of force are made to flow around a conductor in a right-handed or clockwise direction when the observer is looking along the conductor in the direction of the current, or toward the south pole of the generator. Similarly, in an induced or electro-magnet, an electric current is made to flow around the core of the magnet right-handed when the observer is looking in the direction of the lines of force in the core, or toward the south pole of the magnet.

The directions of lines of force are usually discovered by the effect produced upon a small permanent magnet or magnetic needle, which will always come to rest with its north pole pointing in the direction in which they flow through it. Then since the direction of a current depends upon the direction in which the lines of force flow round it, the former also is discovered by noticing the way in which the needle is deflected by the latter.

As there are two directions in which the current may flow through the conductor, and two positions in which the needle may be placed relative to it (above or below), it has been found necessary to use some *memoria technica* to quickly determine the direction of the current, from the way in which it deflects a needle; and among several devices that have been proposed, the following are most used, although they all present certain difficulties.

Ampère's rule is to imagine an observer swimming with the current in a conductor, with his face always toward the north pole of the needle, which will then be deflected toward his left hand. The disadvantages of this rule are the difficulty of imagining the direction of the observer's left hand when he is placed in unusual positions, and the fact that it was intended for determining the deflection of the needle from the direction of the current which it pre-supposes to be known, and it must therefore be used inversely for our purpose.

Another device is to remember the fact that when a current flows from South to North Over a needle, its north pole points West, by noticing that the direction initials spell the word SNOW; and similarly a third rule impresses the statement that when a current flows from North Over a needle to South its north pole points East, by spelling the word NOSE with the direction initials. A vital point that seems to be most troublesome to remember in these, is whether the current is over the needle or *vice versa*, and the difficulty of always finding a part of the conductor running north and south interferes with their direct application.

None of these devices can be used to predict the direction of the current that will be induced in a conductor when it is moved in a certain direction through a known magnetic field, and for this purpose the only one familiar to the writer is to use the right hand with (*a*) the thumb, (*b*) the first and (*c*) the second finger pointed outward in the three rectangular directions to represent respectively (*a*) the direction in which the conductor is moved, (*b*) the direction of the lines of force, and (*c*) the direction of the induced current. The trouble in applying this is to remember which hand to use and what each finger represents.

As an addition to these, and as an analogy that is not liable to confusion, the following experiment is suggested: If a small weight be suspended at the end of a piece of string (fig. 1), the force of the weight acts downward in the

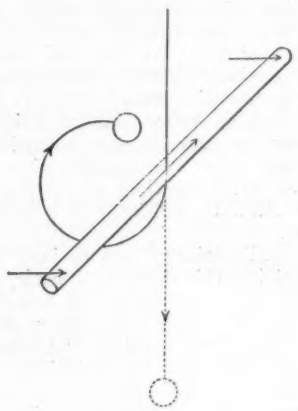


FIG. 1.

direction of the string, and the latter may be used to represent a "line of force" acting vertically downward. If, then, a horizontal rod, which may be used to represent a "conductor," be moved from left to right so as to strike sharply against the string a short distance above the weight, the latter with its "line of force" will revolve around the rod or "conductor" right-handed—a correct analogy to the phenomenon of electric induction. To represent lines of force acting horizontally in either direction or vertically upward, the string may be held opposite or below a rod over which it is passed (fig. 2), the force of the weight on

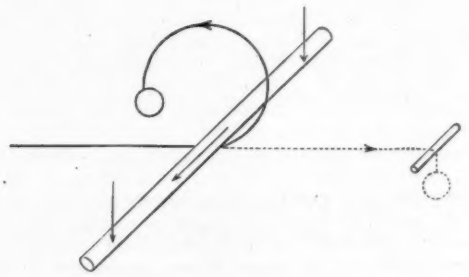


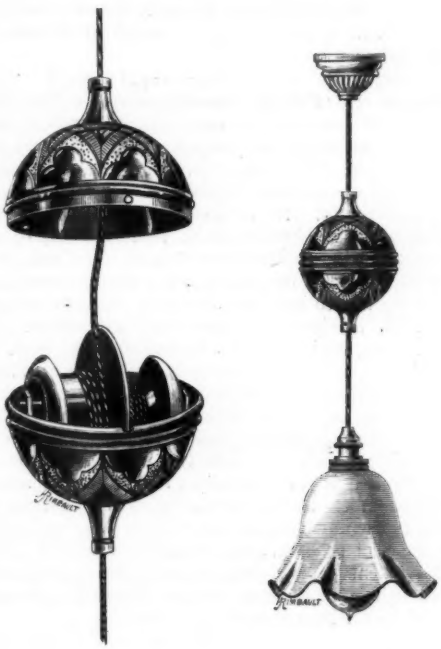
FIG. 2.

its end acting along it in the proper direction. The rod may then be moved as desired, and the resulting revolution of the weight and string will remain a correct analogy for electric induction under similar circumstances. Then knowing the direction of the lines of force around the conductor in any case, the direction of the induced current flowing through it is readily determined by remembering that the observer is looking in the direction of the current when the lines of force flow right-handed around the conductor.

* Read at the stated meeting of the Frankin Institute Electrical Section, April 7th 1891.

NOTES.

The Bradner Adjustable Hanger.—This is a simple but ingenious arrangement for raising and lowering incandescent lamps which are suspended by a single flexible cord from ceilings, &c. It effects the same purpose as the method usually employed with pulley attachments, weight, and three parallel cords, and in a much more sightly and symmetrical manner, as the brass ball appears to be merely an ornament, to break the line of the long straight cord. It will be found of great use in offices, &c., to enable the lamps to be pushed out of the way when not burning, or brought close down over the work when they are alight. When the lamp is pushed up the ball descends, winding up the slack cord on one side of the drum, and unwinding it on the other. The pulley is so weighted as to balance any ordinary lamp shade, holder and lamp, but to meet the case of extra heavy shades, some lead discs are sent out with each hanger, which can be



placed inside the drum. It should be noted that no spring whatever is used, and the lamp remains in any desired position without the slightest difficulty. Any lamp hung by a simple cord suspension can be given an up and down movement by means of the Bradner hanger, and a 10 C.P. lamp will then often be as effective as a 16 C.P. lamp in a fixed position. Messrs. Miller and Woods, of 34, Gray's Inn Road, London, are the makers of this ingenious arrangement.

A New Halifax Cable.—The *New York Times*, of May 11th, is responsible for the announcement that a cable will be laid during the present year between Halifax (Nova Scotia), the West Indies and British Guiana. It is stated that Mr. Gisborne, of the Canadian Telegraphs, has recently visited the various islands collecting information as to routes and traffic possibilities. We are further informed that the necessary capital for carrying out the undertaking is ready in England, and that it is generally believed that the British Government is supporting the enterprise. No mention of telegraphy, in connection with the West Indies, would be complete without some allusion to the excessive rates levied by the West India and Panama Company, and it is affirmed that the new cables will compete with the elder company at about half the present tariffs.

With regard to the above, we (the Editors of the ELECTRICAL REVIEW), learn on good authority that the allusion to the British Government has no foundation in fact.

The Pouyer-Quertier Cable Company.—The General meeting of the shareholders of the Compagnie Française du Télégraphe de Paris à New York, was held on 20th May. The accounts for 1890 were approved and passed, and authorisation was given for the issue of sufficient bonds to produce an effective capital of 12 million francs. Full powers were given to the Council of Administration to take such steps as the best interests of the company might demand.

Personal.—Mr. Rankin Kennedy has commenced work in the new factory at Carntyne, Glasgow, and has secured the contract for the complete outfit for electric light and power at the Hartwood Asylum, now building for the Lanarkshire Lunacy Board. In this installation there are three Robey compound automatic expansion engines belted direct on to three special dynamos of Kennedy's single bobbin type. These dynamos are very slow speed and very massive in design. The boilers are to be Galloway's tubular boilers. The installation is extensive and very complete, as the whole of the buildings, which cover a large area, are to be entirely dependent on electricity for lighting. Complete electric light outfits are also in hand for two steamships, the ss. *Labarmati* and the ss. *Brahmani*, building by Messrs. Dunsmuir and Jackson, Govan, Glasgow. Mr. Kennedy is now pushing the introduction of motors on shipboard, driven by electricity, to take the place of the small steam engines used for pumps, forced draught, freezing machines, capstans, &c., &c. For such small powers alternating currents and commutatorless motors are advocated.

A New Use for the Electric Light.—By the aid of the electric light the Botanical Mission despatched some months since by the authorities of Kew to the West Indies were extricated, according to the *St. James's Gazette*, from an embarrassing dilemma. They had with them a number of Wardian cases containing vine cuttings and Gambier plants, which it was deemed very desirable to introduce into this island; but, unfortunately, cold weather set in, and the efforts to convey these tender plants, which had so often ended in failure, threatened once more to result in disappointment. The difficulty was that if kept on deck they would be inevitably destroyed by the low temperature; while if taken below, the absence of light, which is so necessary to the existence of the delicate Gambier plants, was almost certain to be equally fatal. Under these circumstances it occurred to Mr. Morris to avail himself of the electric light which was aboard the *Atrato*. The experiment proved in every way successful. Mr. Morris expresses the opinion that the use of the electric light for the safe passage of valuable plants during the winter months is capable of being greatly extended.

A New Form of Compass.—In May, 1881, Mons. H. Wild published in the *Bulletin de l'Académie Impériale des Sciences de Saint Pétersbourg* a short account of a new method of determining the magnetic declination with the "Weber induction compass." This method was designed to eliminate the experimental errors due to the sensitiveness of the galvanometers employed ranging with the deviation of the magnet (*vide Bulletin*, Vol. xxvii.). This method was also the subject of a communication to the Paris Academy of Science in 1884, in which Mons. Wild more fully described his new method of determining the declination, and also gave an account of the results obtained with it (*vide Comptes Rendus*, Vol. xcviii., p. 91). Being convinced that the induction compass, if conveniently arranged, might be used to determine the absolute magnetic inclination with the same accuracy as the absolute declination, Mons. Wild had constructed in the workshop of the central physical observatory an instrument of great precision. In the spring of 1890 this instrument was set up in the magnetic observatory at Pawlowsk, and from June of that year to December a large number of experiments was made with it by three different persons. From a comparison of the experimental results it appears that the absolute inclination can be determined with this new compass by means of Mons. Wild's method in a single observation, the mean error being within the limits $\pm 4''\cdot5$. But with a little practice this experimental error can be reduced within the limits $\pm 2''\cdot5$. Hence the absolute inclination can now be determined in the same simple manner and with the same accuracy as the declination.

Fire at the Frankfort Exhibition.—On the opening day a fire broke out in the great panorama representing "The Arrival of a North German Lloyd Steamer in the Harbour of New York." The fire occurred at 7 o'clock in the evening, and is said to have been caused by sparks from an arc lamp falling upon an asphalte covered screen. It was soon put out by a few buckets of water, and no damage was done to the paintings.

Cuttriss Motors.—The newly-constituted firm of Cuttriss, Wallis & Co., Limited, has published an illustrated catalogue of dynamos, motors, and electrical appliances manufactured at the Elmwood Electrical Works, Leeds. The company expresses its determination to make every effort to keep to the front in the manufacture of electric motors, a branch of business with which the name of Cuttriss has been for a long time associated.

Engineers' Stores for Electric Light Companies.—Messrs. W. H. Willcox and Co., of 36, Southwark Street, who have for some years given special attention to the requirements of electrical engineers in the way of lubricating oils, belting, engine packing, tools, and general stores, have prospered so well in their endeavours that they now find it necessary to enlarge their premises. They have, therefore, taken the adjoining warehouse (No. 34), so as to have greater facilities for despatching orders and be able to hold a much heavier and more assorted stock.

New Electric Launch.—Messrs. Escher, Wyss & Co., of the Oerlikon Engineering Works, have built a large electric launch, which is now being experimented with on the Lake of Zürich. The current is furnished by 56 cells, which yield sufficient energy to operate the boat for from five to six hours. The motor is coupled direct to the shaft of the propeller, and the maximum speed is 6¼ miles an hour. The launch will carry 100 passengers, and is intended to travel from the left to the right bank of the Main at the Frankfort Exhibition.

The New A.E.G. Incandescent Lamp.—The Allegemeine Elektricitäts Gesellschaft of Berlin has within the last year brought a very efficient glow lamp into the market. The old Edison lamps made by this firm lost under normal conditions about 20 per cent. of their illuminating power after 300 to 400 hours' use. With the new and improved filament this loss does not occur until after 600 hours' use. The A.E.G. Company makes a lamp which does not suffer in the least when continually subjected to 104 volts, and yet gives 16 C.P. at 100 volts. The mean efficiency is 3·1 watts per C.P. For small rooms 5 C.P. lamps are in general use which consume only two-fifths of the standard 16 C.P. lamp. The Keys' Electric Company, Limited, of London have the agency for this lamp for export only.

Extraordinary Incident on the Channel Telephone Line.—A telegram to the *Standard*, dated the 27th inst., reads as follows:—"An extraordinary accident occurred yesterday with the London-Paris telephone office in the Palais de la Bourse. One of the *employés*, a gentleman named Weller, wished to communicate with the London office on a matter of service. He had already rung up the English officials, and, the bell having sounded in reply, took up the receivers and put them to his ears, when he suddenly sustained a shock of electricity of such severity that it threw him staggering backwards against the door of the telephone cabinet, which, not having being properly fastened, flew open, with the result that he was thrown heavily to the ground. He was injured on the forehead and across his right eye, but whether the bruises were due to the fall or were caused by the instrument is not certain. M. Weller suffered from the shock, but was able to resume duty this morning. It appears from enquiries that similar accidents, although less serious, have occurred at this telephone office on several previous occasions. The officials attribute them to lightning striking the wire either at San Gatte, where the submarine cable ends, or at the terminus of the land wire on the Palais de la Bourse. Such accidents, it is declared, can easily be prevented by the simple expedient of erecting lightning conductors at the point where the cable comes ashore and at the terminus in Paris." On this side the land line between London and the cable is thoroughly and efficiently guarded with lightning protectors, so that such an accident would be impossible here.

Electrical Transmission and Conversion of Energy.—We are again indebted to the courtesy of Mr. H. Ward Leonard for advance proofs of another of his interesting papers, which we publish on p. 683.

High and Low Pressure Central Stations.—It is not likely that Mr. Crompton will leave Mr. Addenbrooke's article, which appears in this issue, unchallenged, so the "Acute Form of the Old Question" will not be confined to the walls of the Institution of Electrical Engineers.

The Popp Compressed Air System.—According to *Elektricitäts Zeitung*, the Compagnie Parisienne de l'Air Comprimé is unable to declare a dividend for the past financial year. The installations in Paris of this company have swallowed 27,000,000 francs, and many more millions are necessary to complete the work in the allotted district. The capital of the company has mostly been underwritten at discounts by a certain financial group, and it is said that the International Compressed Air Company of Berlin has advanced 15,000,000 francs. Repeated but fruitless attempts have been made to get the shares quoted by Parisian Banking establishments.

Verbiage in Patent Specifications.—The *Engineer* of New York has the following note in a recent issue:—"Sometimes we laugh at lawyers and their legal phrases, their aforesaids, whereases, &c., &c., but we might with more propriety put a lance in rest for our friend the patent specification writer. He is the tedious, turgid, too effulgent parent of sonorous phrases, which mean too much, or mean nothing, according to their connection. You will never get him to tell the truth in plain words; he abhors such a practice. If he has to say that there is a hole through a spool, he says: 'It is given a longitudinal perforation.' This is much more secure in a patent than the word 'hole,' for the latter might be evaded in some way, but no one could possibly frustrate a longitudinal perforation. The patent specification writer will not say a casting is made in one piece; he will say it is 'integral,' and if he has to say that one piece is near another piece, he will not state that fact as we have, but he will say that it is 'in adjacency to it;' he will also assert that one chamber circumscribes another in preference to saying that it surrounds it, and he will, in other ways, so befog and mask what he should say, that he succeeds in producing a claim that may mean any one of half a dozen readings, when the whole facts could be told in simple language that admits of no misinterpretation whatever."

Submarine Cable Manufacture in France.—The issue of *L'Electricien* for May 23rd contains an illustrated article on the progress of submarine cable industry in France. As a matter of course, the major portion of the matter is devoted to a description of the new cable factory at Calais constructed last year by the Société Générale des Telephones, since these are the only works in France capable of turning out any considerable quantity of cable. The Government cable works at La Seyne (Toulon) are not adapted to undertake the manufacture of an important length of cable, although, notwithstanding their restricted means, they have recently completed 350 kilometres intended to connect Corsica with Toulon; they are also dependent on private firms for their core, their operations being confined to the laying on of sheathing wires. It is stated that the gutta-percha works of the Société Générale des Téléphones at Bezons can turn out more than 20 nautical miles of core per diem, while the factory at Calais can daily sheath from 20 to 25 nautical miles of submarine cable. The sheathing machines are eight in number, but we are not informed as to what sizes of cable can be sheathed by them. We understand, however, that they are only adapted to light types, and that for the heavier cables, such as shore ends and intermediates, English manufacturers must still be depended on. But whatever may be the actual capabilities of the Calais works, and though we may be inclined to smile at the somewhat exaggerated satisfaction manifested by the French Press at the establishment of the new enterprise, some measure of praise must be accorded to the men who have advanced this particular industry to its present stage.

The Palermo Exhibition.—This Exhibition will be lighted by 300 10-ampère arc lamps, arranged two in series, and by 1,100 16-C.P. glow lamps. Five Siemens dynamos will supply the current, whilst a sixth machine will operate the electromotors which will drive the lift in the Exhibition tower.

Work Exhibition.—A second work exhibition will be opened in Paris, in the Palais de l'Industrie, towards the end of July. Motive power will be provided free of charge, and the lighting of the machinery hall will also be gratuitous. These concessions have induced several French electrical firms to participate in the exhibition.

An American Electrician Attacked in Italy.—Mr. William W. Jacques, the electrician of the American Bell Telephone Company, who has been travelling in Italy with his family, was savagely attacked recently in Florence by a mob of Italians. He was riding in a carriage with his daughter, and was pursued by the crowd, which pelted the couple with stones, severely injuring his daughter. The assault was unprovoked.

"The First Electrical Crane Catalogue ever Published."—And we should say it is not likely to be the last! We refer to a book just issued by Messrs. R. Bolton & Co., which opens a new field of operations for electrical engineers. Here is evidenced a wide opening for electro-motors of all sizes, and no readier opportunity exists for the adaptation of electric force to industrial purposes. Mr. Reginald Bolton, who is the author of the pamphlet, has read a paper on the subject during the past winter, and has evidently made a close study of the matter. We shall shortly illustrate his patent electrical ship's winch, which contains mechanical features of considerable novelty and interest. Meantime we recommend our electrical readers to interest themselves in the introduction of this new adaptation of electricity to machinery.

The Electric Light at Southampton.—At a meeting of the Southampton Pier and Harbour Board last week the Special and General Works Committee reported that they had had before them the draft form of an agreement with the Southampton Electric Light and Power Company for the supply of electrical energy for cranes and lighting purposes on the quay and pier, the arrangement being proposed to be for seven years, and the board guaranteeing a minimum payment of £200 per annum. The committee recommended the adoption of the proposed agreement. Objection was taken to it because of its binding the board for seven years, whereas the company do not compel any private consumer to bind himself in such a manner. It was proposed that the matter should be deferred until a future meeting, and eventually this was agreed to, it being also decided that a copy of the draft agreement should be sent to each member of the board.

Edmond Becquerel.— Edmond Becquerel is a name which is very familiar to scientists of the electrical profession, and his death which took place recently, has removed a distinguished physicist from scientific circles. Born in 1820, Becquerel became a Doctor of Science in 1840. In 1850 he held the chair of physics and meteorology at the Institute of Versailles, and on the suppression of this establishment in 1850 he was nominated Professor of Applied Physics at the Conservatoire des Arts et Metiers. In 1863 he was elected a member of the Academie des Sciences. From 1838 he never ceased to publish numerous memoirs relative to electricity, magnetism, optics and meteorology. His best known work relative to electricity related to the laws of electrothermal decomposition of bodies, the development of heat by the passage of electricity in circuits, the production of electricity by mechanical action, and the physical and chemical properties of electrified bodies. In 1849—55 he studied the action of magnetism on all bodies; he discovered that oxygen was magnetic. In 1855-56 he published a treatise on Electricity and Magnetism, and in 1858 a history of Electricity and Magnetism. A very methodical professor and an eloquent and painstaking lecturer, his loss is one which will be much felt.

NEW COMPANIES REGISTERED.

Woodfield Syndicate, Limited. — Capital £12,000, divided into 10,000 "A" shares, 1,000 "B" shares, and 1,000 "C" shares of £1 each. Objects: To carry on the business of an electrical company in all its branches; to carry on the business of electricians, electrical contractors, electrical and mechanical engineers, suppliers of electricity for the purposes of light, heat, sound, power or otherwise, and of manufacturers of and dealers in all apparatus required for the generation, distribution, supply, accumulation and employment of electricity, and to carry on the business of a telephone, telegraph, or other company. Signatories (with 1 "A" share each), W. E. Townsend, 21, Argyle Road, Ealing; S. Evershed, Henley; J. Richards, 45, Northumberland Place, W.; A. Huss, Ockbrooke, Lower Edmonton; A. Schreider, 21, Bolingbroke Road, W.; H. W. Cole, 121, Droop Street, Kensal Green, W.; T. M. Tuley, 156, Ashmore Road, W. The number of directors is not to be less than two, nor more than five, the first to be elected by the subscribers. Qualification, the holding of shares or stock. Remuneration to be determined in general meeting. Registered on the 16th inst. by Guscotte and Fowler, 1, York Buildings, Adelphi. Office, Woodfield Road, Harrow Road, N.W.

Clegg's Metal Incandescent Lamp Company of France, Limited. — Capital, £10,000 in £10 shares. Objects: To enter into an agreement, dated the 13th May, 1891, made between J. Clegg, of the first part, Betts & Co., Limited, of the second part, and the company of the third part, to develop and carry on the manufacture and sale of electric lamps and other electrical appliances, and to purchase and carry on the business of electricians, mechanical, and electrical engineers, manufacturers of iron and brass, boiler makers, metallurgists, &c. Signatories (with 1 share each): Col. A. Maclean, Royal Dragoons, Colchester; L. D. Ryder, Park Lodge, Bracknell; C. Cheswright, 1, Wharf Road, City Road, N.; A. Campbell, 1, Wharf Road, City Road, N.; C. Cheswright, jun., 1, Wharf Road, City Road, N.; J. Clegg, Connaught Mansions, Westminster; J. S. Spencer, 175, Camden Grove, N. The number of directors not to be less than three nor more than eight, the first being the above subscribers in addition to one other nominated by J. Clegg. Registered on the 20th inst. by Bircham & Co., solicitors to the company, 46, Parliament Street, Westminster, S.W.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Electric Stores, Limited.—The statutory return of this company made up to the 1st inst., was filed on the 4th inst. The nominal capital is £15,000 in £1 shares. Seven shares have been taken up, but upon these no call has been made. Office, 51, Cannon Street, London, E.C.

Electrical Advertising Syndicate, Limited.—The registered office of this company is situated at Victoria Mansions, Victoria Street, Westminster, S.W.

CITY NOTES.

The Consolidated Telephone Construction and Maintenance Company, Limited.

C. L. W. FITZGERALD, Esq., presided at the meeting held at Cannon Street Hotel yesterday. Referring to the report published in our last issue, he said the profit amounted to £11,573 8s. 9d., which, with the amount brought forward from last year, left a balance of £13,416 6s. 8d. The first item he would call their attention to was that the profit this year was less than last by £253. If they considered all things, it was not at all bad. They had received more dividends from subsidiary companies by the sum of £534, and this despite the fact that they had only received from the River Plate investment £50 instead of £250. Expenses were a little higher than last year. Plant and machinery was valued this year at about £250 less than it was last year. They had added considerably to the plant, and were getting some fine new machinery. He could safely say that the plant was never in a more efficient state than at present. At the moment he was engaged with the officials of the company in entirely reorganising the plant to enable the turning out of more goods. They would see that stock amounted to the sum of £6,895, which he was happy to say was a decrease since last year. The subsidiary companies owed to them the sum total of £8,993, and they only owed £1,669 8s. 10d. They had not

asked the shareholders for any money in the form of preference shares, which had been done on the last two occasions.

The CHAIRMAN, after referring to other investments of the company, answered several questions, and the proceedings terminated.

The Notting Hill Electric Lighting Company, Limited.

THE directors' report, to be presented to the adjourned meeting on Saturday says:—

It will be observed that the expenditure on capital account covers a period of nearly three years, from the 21st February, 1888 (the date of incorporation of the company) to the 31st December, 1890. As, however, before the publication of the prospectus in January, 1890, no shares were issued beyond a few originally subscribed for and paid up in full by the founders of the company, the bulk of the expenditure on the works has been incurred during a period of less than 12 months.

On the 31st December, 1890, the capital paid up was £42,576, and the liability on the shares issued amounted to £27,444, and there remained £29,980 of unissued capital.

Altogether 7,002 shares have been subscribed, and a special settlement was obtained on the Stock Exchange on the 1st July, 1890, for the 6,318 ordinary shares of £10 each, which were applied for and allotted in accordance with the prospectus, and an application has been lodged with the Stock Exchange Committee for a quotation of these shares upon the official list.

The capital expenditure, as shown by the accounts, amounted at the end of the year to £43,126 5s. 2d., but this sum does not include the further liabilities on contracts entered into for construction of buildings, mains and machinery, since nearly completed. These amount to about £12,000, bringing the total of expenditure incurred and contracted for before the date of the opening of the works to about £55,500.

Subsequent to the purchase of the lease of the property for a central station in Victoria Gardens, Notting Hill, which is referred to in the prospectus, the directors took the opportunity which offered itself of acquiring the freehold. It also became necessary, owing to injunctions which were obtained during the construction of the central station by the owners of neighbouring property, to purchase the lease of seven small houses adjoining in Bulmer Place. These houses are all let.

Considerable delay occurred in the completion of the works, owing, in the first place, to the injunctions above mentioned, and when the work could have been resumed the very severe weather supervened, thus making it impossible for the contractors to proceed for a considerable time with the building of the central station. The directors are, however, glad to state that the central station has been now completed, and the company is able to supply the electric current to houses situated in the principal streets of the northern and central portion of the area of supply, in which the mains have already been fixed.

The number of houses in the district which are prepared to tak the light is continually increasing. Already the owners of 70 houses have notified their readiness to take the light. This number includes Holland House, and it is estimated that at the present time the installations comprise a total number of about 4,000 lamps reduced as usual to 8 candle-power. The engineers have reason to believe that a considerable number of householders are intending to have their houses wired as soon as the current is actually being delivered, and it is expected that before next winter the generation of the amount of electrical current supplied to customers will profitably occupy the whole of the existing plant.

Much difficulty has been experienced in obtaining a site for a second central station, but a provisional contract has now been entered into in reference to a site which the directors consider well suited for the purpose, and as soon as the agreement is completed, steps will be taken to lay the mains in the southern part of the district, when the whole of the parliamentary area granted to the company can be supplied with the electric current.

In this southern district an increase in the number of customers is to be expected, in consequence of the decision of Lord Ilchester to let for building purposes about 2¼ acres of Holland Park.

The directors who retire are Messrs. A. Howden and J. T. Jarvis, who, being eligible, offer themselves for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths & Co., retire, and being eligible, offer themselves for re-election.

ABSTRACT OF ACCOUNTS from February 21st, 1888, to December 31st, 1890.

CAPITAL ACCOUNT.

Dr.	£	s.	d.
To Lands and property	7,390	0	0
„ Buildings	6,476	17	8
„ Fixed machinery	2,777	11	3
„ Accumulators	1,164	0	0
„ Mains	18,347	15	10
„ Cost of license, &c.	4,001	15	6
„ Local office	393	14	0
„ Law costs	539	3	8
„ Directors' fees, &c.	1,446	17	0
„ Cost of opposing injunctions, &c.	435	0	0
„ Rent, rates, taxes, printing, stationery, &c., less sundry receipts (£235)	153	10	3
	£43,126	5	2

Cr.	£	s.	d.
By Ordinary shares (less amount uncalled)	39,248	0	0
„ Founders' shares (less amount uncalled)	3,328	0	0
„ Balance	550	5	2
	£43,126	5	2

GENERAL BALANCE SHEET.

Dr.	£	s.	d.
To Capital account	42,576	0	0
„ Sundry tradesmen and others on contracts for mains and machinery in course of construction, &c.	7,668	17	9
	£50,244	17	9

Cr.	£	s.	d.
By Capital account	43,126	5	2
„ Cash at bankers	6,641	0	8
„ Cash in hand	25	0	0
„ Debtors for rent	31	7	9
„ Stock (movable plant and tools)	421	4	2
	£50,244	17	9

City of London Electric Lighting (Pioneer) Company.

THE statutory meeting of the City of London Electric Lighting (Pioneer) Company, Limited, was held last Monday at Winchester House, Old Broad Street, the Lord Mayor presiding.

The CHAIRMAN said the shareholders would be glad to hear that notwithstanding the great financial depression and difficulties which prevailed four months ago, the directors were enabled to launch the company most satisfactorily. The capital was applied for nearly three times over, and they were thus able to arrange for its launching on most economical terms. The object of the Pioneer Company was merely to provide capital to enable the contractors, who had obtained concessions from the Commissioners of Sewers, with the authority of the Board of Trade, to proceed with the work which they had undertaken, the Pioneer Company reserving to themselves the right to launch at some future time a larger company, which should take over from the contractors the concessions which they had secured. In the early days of the company the directors summoned all the leading electricians of the day to meet them, with the view of ascertaining their opinion as to the best methods of lighting the City of London. They considered the methods recommended by the board to be the best, and the company was now engaged carrying out the recommendations which were then arrived at. The directors felt certain that when the electric lighting of the City was complete, it would be second to none in the world. The contractors had secured most suitable sites to place their machinery, that for the eastern district being near Tower Hill, and that for the central and western districts being on Bankside. The work was so far advanced that they hoped Queen Victoria Street would be lighted by electricty before the middle of next month. The board had been doing a great deal of preparatory work, in order to assist them in organising the new company, which it was proposed to found at no distant date. The formation of this company was in the hands of men of such very high standing and undoubted reputation, that he felt confident it would secure not only a fair remuneration to those shareholders who might join it, but also secure for the City of London a most perfect and unique system of lighting.

Mr. EDWARD LEE asked if the capital of £50,000 would be sufficient for the purposes of the Pioneer Company?

The CHAIRMAN: We think it is ample.

Votes of thanks concluded the proceedings.

Indo-European Telegraph Company.—At an extraordinary general meeting held on Monday, at the offices, Old Broad Street, Mr. J. H. Tritton in the chair, the resolution passed at the meeting on the 28th ult.—in effect providing that the managing director should be a member of the board—was unanimously confirmed.

TRAFFIC RECEIPTS.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ended May 22nd, 1891, amounted to £4,730.

The City and South London Railway Company. Traffic receipts for the past week, were £768.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending May 22nd, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Company, were £3,803.

SHARE LIST OF ELECTRICAL COMPANIES.

Present Amount Issued.	Name.	Stock or Share.	Closing Quotation. (May 21).	Closing Quotation. (May 28.)	Business done during week ending May 28, 1891. Highest.	Lowest.
250,000*l*	African Direct Telegraph, Ltd., 4 p. c., Deb. Regd. and to Bearer	100	99 —102	99 —102	100	...
1,381,380*l*	Anglo-American Telegraph, Limited	Stock	46½— 47½	46½— 47½	...	...
2,809,310*l*	Do. do. 6 p. c. Preferred	Stock	84 — 85	84½— 85½	85½	85¼
2,809,310*l*	Do. do. Deferred	Stock	11½— 12	11⅞— 12	12	...
130,000	Brazilian Submarine Telegraph, Limited	10	11⅞— 12¼	11⅞— 12¼	12¼	11⅞
84,500*l*	Do. do. 5 p. c. Bonds	100	101 —104	101 —104	...	...
75,000*l*	Do. do. 5 p. c., 2nd Series, repayable in June, 1906 ...	100	104 —108	104 —108	104½	...
63,416	Brush Electric Engineering Ordinary, Nos. 1 to 63,416	3	2½— 2⅞	2⅛— 2⅜	2 5/16	...
63,416	Do. do. Non cum. Preference, Nos. 1 to 63,416	2	1⅜— 1⅝	1⅜— 1⅝	1½	1 1/16
50,000	City and South London Railway, Nos. 1 to 50,000	10	5½— 6⅛	5 — 6	...	...
$7,216,000	Commercial Cable, Capital Stock	$100	108 —110	106 —108	...	...
224,850	Consolidated Telephone Construction and Maintenance, Limited ...	14/-	½— ⅝	½— ⅝	½	...
20,000	Crompton & Co., Ltd, 7 p. c. Preference Shares, Nos. 1 to 20,000	Stock	4 — 5	4 — 5	...	...
16,000	Cuba Telegraph, Limited	10	10½— 11½	10½— 11½	11	...
6,000	Do. do. 10 p. c. Preference	10	16½— 17½	16½— 17½	...	...
12,931	Direct Spanish Telegraph, Limited, ... (£4 only paid)	5	3¾— 4¼	3¾— 4¼	...	...
6,000	Do. do. 10 p. c. Preference	5	9 — 10	9 — 10	...	...
60,710	Direct United States Cable, Limited, 1877	20	10½— 10½	10½— 10½	10 7/16	10¼
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	14⅜— 14⅝	14⅜— 14⅝	14⅝	14 5/16
70,000	Do. 6 p. c. Preference	10	15½— 15⅝	15½— 15⅝	15⅝	15½
200,000*l*	Do. 5 p. c. Debs. (1879 issue), repay. August, 1899	100	107 —110	107 —110	108⅛	107
1,200,000*l*	Do. 4 p. c. Mortgage Debenture Stock	Stock	106 —109	106 —109	108⅞	106½
250,000	Eastern Extension, Australasia and China Telegraph, Limited ...	10	14⅞— 15¼	14⅞— 15	15	14⅞
91,800*l*	Do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	103 —106	103 —106	...	...
325,200*l*	Do. do. Bearer Nos. 1050—3,975 and 4,327—6,400 ...	100	103 —106	103 —106	...	...
320,000*l*	Do. 4 p. c. Debenture Stock	Stock	106 —108	105 —108	...	...
135,000*l*	Eastern and South African Telegraph, Ltd., 5 p. c. Mort. Deb. 1900 redeem. ann. drawings, Registered Nos. 1 to 2,343	100	103 —106	103 —106	103¼	103
180,400*l*	Do. do. do. to bearer, Nos. 2,344 to 5,500	...	103 —106	103 —106	105	...
201,600*l*	Do. do. 4 p. c. Mort. Debs. Nos. 1 to 2016, red. 1909	100	99 —101	99 —101	...	...
45,000	Electric Construction, Limited, Nos. 101 to 45,100	10	5 — 6	5 — 6	...	...
19,900	*Electricity Supply Co. of Spain, Nos. 101 to 20,000	5	4½— 5	4½— 5	...	...
66,750	Elmore's French Patent Copper Depositing Co., Ltd, Nos. 1 to 66,750	2	1⅜— 1⅝	1⅜— 2¼	2 5/16	2
70,000	Elmore's Patent Copper Depositing, Limited., Nos. 1 to 70,000 ...	2	2 — 2½	2½— 3	3	2½
67,385	Elmore's Wire Mfg., Ltd., Nos. 1 to 67,385, issued at 1 p.m., all pd.	2	1 — 1½	1 — 1½	...	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300 ... (£4 only paid)	5	2½— 3½	2½— 3½	...	...
180,227	Globe Telegraph and Trust, Limited	10	9¼— 9½	9¼— 9½	9½	9⅜
180,042	Do. do. 6 p. c. Preference	10	14⅞— 15⅝	15 — 15½	15 1/16	14⅞
150,000	Great Northern Tel. Company of Copenhagen	10	17½— 18½	18¼— 18⅝	18½	18
230,000*l*	Do. do. 5 p. c. Debs. (issue of 1883) ...	100	105 —108	105 —108	...	...
9,334*l*	Greenwood and Batley, Ltd., Ordinary, Nos. 4667 to 14,000 ...	10	10 — 11	10 — 11	...	...
5,334*l*	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	11 — 12	11 — 12	...	...
41,600	India-Rubber, Gutta Percha and Telegraph Works, Limited ...	10	18½— 19½	18½— 19½	19½	19¼
200,000*l*	Do. do. 4½ p. c., Deb., 1896	100	102 —104	102 —104	...	...
17,000	Indo-European Telegraph, Limited	25	39 — 41	39 — 41	40¼	...
11,334	International Okonite, Ltd., Ordinary Nos. 22,667 to 34,000	10	7½— 8½	7½— 8½	...	...
11,334	Do. do. Preference Nos. 5,667 to 17,000 ...	10	9¼— 9⅞	9½— 9⅞	...	...
38,348	London Platino-Brazilian Telegraph, Limited	10	6¾— 7½xd	6¾— 7½	...	...
100,000*l*	Do. do. do. 6 p. c. Debentures	100	106 —109	106 —109	...	...
43,900	*Metropolitan Electric Supply, Ltd., Nos. 6,101 to 50,000 (£9 paid)	10	9 — 9½	9 — 9½	9¼	...
438,984	National Telephone, Limited, Nos. 1. to 438,984	5	4⅝— 4⅞	4⅝— 4⅞	4 13/16	4⅝
15,000	Do. 6 p. c. Cum., 1st Preference	10	12½— 13	12½— 13	...	...
15,000	Do. 6. p. c. Cum. 2nd Preference (£8 only paid)	10	12 — 12½	12 — 12½	12⅜	...
350,000	Do. 4½ p.c. Deb. Stock Prov. Certs. fully paid ...	...	103 —105	103 —105	104	104½
220,000	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11s. only paid)	1	¼— ⅜	¼— ⅜	...	...
9,000	Reuter's Limited	8	8 — 8½xd	8 — 8½	...	...
209,750	South of England Telephone, Limited, Ordinary Nos. 1 to 2,000, 2,501 to 3,500, 93,251 to 300,000	1	⅛— ¼	⅛— ¼	...	...
20,000	Do. 6 p. c. Cum. Pref., Nos. 1 to 20,000 (£3½ only paid)	5	3 — 3½	3 — 3½	...	...
3,381	Submarine Cables Trust	Cert.	116 —121	115 —120	116	...
78,949	Swan United Electric Light, Limited ... ... (£3½ only paid)	5	4½— 5 xd	4½— 4⅝	...	...
37,350	Telegraph Construction and Maintenance, Limited	12	46 — 48	45 — 47	47	45½
150,000*l*	Do. do. do. 5 p. c. Bonds, red. 1894	100	102 —105	102 —105	...	...
58,000	United River Plate Telephone, Limited	5	2½— 3½	2½— 3½	...	...
146,128*l*	Do. do. 5 p. c. Debenture Stock ...	Stock	85 — 95	85 — 95	...	...
3,200*l*	Do. do. 7 p. c. Debs., Nos. 1 to 1,000 ...	100	... ...	... ...	...	...
15,609	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	8 — 9	8 — 9	...	...
290,900*l*	Do. do. do. 5 p. c. Debentures	100	96 — 99	96 — 99	98	...
30,000	West Coast of America Telegraph, Limited	10	3½— 4¼	3⅜— 4¼xd	...	...
150,000*l*	Do. do. do. 8 p. c. Debs., repayable 1902 ...	100	100 — 105	100 — 105	...	...
64,174	Western and Brazilian Telegraph, Limited	15	11 — 11¼xd	11 — 11½	11 5/16	11¼
27,873	Do. do. do. 5 p. c. Cum. Preferred	7½	6½— 7 xd	6½— 7	...	...
27,873	Do. do. do. 5 p. c. Deferred	7½	4⅝— 5¼xd	4⅝— 5¼	5	...
200,000*l*	Do. do. do. 6 p. c. Debentures "A," 1910 ...	100	103 —106	103 —106	...	...
250,000*l*	Do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	103 —106	103 —106	105½	...
88,321	West India and Panama Telegraph, Limited	10	2⅞— 3⅛	2⅞— 3⅛xd	3 1/16	2 15/16
34,563	Do. do. do. 6 p. c. 1st Preference ...	10	11⅝— 12¼	11⅛— 12⅛xd	12 3/16	11 1/16
4,669	Do. do. do. 6 p. c. 2nd Preference ...	10	11⅛— 12⅛	9⅜— 10¼xd	11¼	...
$1,336,000	Western Union of U.S. Tel., 7 p. c. 1st Mortgage (Building) Bonds	$1,000	117 —122	117 —122	117	...
175,100*l*	Do. do. 6 p. c. Sterling Bonds	100	100—104	100 —104	...	..
42,853	*Westminster Electric Supply Corporation, Ord., Nos. 101 to 42,953	3	4¾— 5¼	4¾—5¼	...	...

* Subject to Founders' Shares.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Blackpool Electric Tramway Company, Limited, £10 (£6½ paid), 7½—7⅝.—City of London Electric Lighting (Pioneer), Shares of £50, £25 paid, 32—34.—Elmore's Austrian Copper Depositing, 15s., 25s.—Elmore's Priorities, 3⅞—4¼.—House to House Company (£5 paid) 4⅜—5½.—Liverpool Electric Supply, £3 paid, 2⅝—2⅞.—London Electric Supply Corporation, Ordinary (£5 paid), 2⅛—2⅜.—Manchester, Edison and Swan Company, £9 (£1 paid) 2s 6d.—5s.—St. James's and Pall Mall Electric Light £5, 5⅞—6½.—St. James's and Pall Mall, 7 per cent. pref., ⅝ to ¾ prem.—Woodhouse and Rawson Ordinary of £5 (£2 10s. paid), 2—2½.—Preference, fully paid 3⅞—4⅜.—Debentures 90—95.—Woods Electric Car, £10 paid, ¾—1.

BANK RATE OF DISCOUNT.—5 per cent. (14th May, 1891).

LEGAL.

Action by the United Telephone Company.—In the Court of Session, Edinburgh, on Wednesday last week, evidence was heard in an action by the United Telephone Company, Limited, London, and the National Telephone Company, Limited, Oxford Court, Cannon Street, London, against Andrew Erskine Muirhead, merchant, Cart Forge, Crossmyloof, Glasgow, to (1) interdict the defender from infringing the pursuers' Edison and Morgan-Brown letters patents; (2) for payment of £500, and (3) for delivery or destruction of all instruments of which he is in possession which infringe these letters patent. It was stated by the pursuers in the petition that they were the owners of the patents, and they had discovered recently that the defender for some time past had been violating and infringing these letters patent. In particular, the defender had for some time prior to the 9th December, 1890, and also subsequent thereto, been supplying to parties and erecting telephone transmitters and receivers, known as Ader transmitters and receivers. These instruments are constructed according to pursuers' letters patent. In particular, the defender had supplied such instruments to Messrs. Merry and Cunninghame, ironmasters, Glasgow, and Messrs. J. and P. Coats, thread manufacturers, Paisley; the Central Agency, Glasgow, and to Mr. James Whyte, photographer, 37, Jamaica Street, Glasgow. The pursuers' trade had thus been interfered and injured by the defender, and they have suffered to the extent of more than £500. The defender in his answer to the petition, admitted that with the knowledge and approval of the pursuers, he used Ader transmitters and receivers for experimental purposes, also that he had erected at the premises of Messrs. Merry and Cunninghame, and of Messrs. J. and P. Coats, Paisley, and at their Central Agency, Glasgow, telephone transmitters and receivers also for experimental purposes. He received no consideration whatever in respect of instruments so used and erected, nor had the pursuers been prejudiced thereby.

A minute was put in on behalf of the defender in which he admitted having supplied to certain firms—Messrs. Merry and Cunninghame and J. and P. Coats and John Chalmers—Ader and Berthon transmitters and Ader receivers; that these were supplied for the purpose of experiment during the currency of the pursuers' patents; that the Ader and Berthon were practically the same; that the sale of the Ader and Berthon transmitters was an infringement of the pursuers' second patent (the carbon transmitter), and that the sale of the Ader receiver prior to 9th December, 1890, was an infringement of the pursuers' first patent (the magnetic receiver.)

On Tuesday, the defender in respect that one patent had expired and that the other would expire in July, offered to consent to the pursuers' obtaining interdict; to deliver to them infringing instruments in his possession, and to pay £50 damages and expenses as between party and party.

Mr. Graham Murray and Mr. Dickson, instructed by Messrs. Davidson and Syme, W.S., appeared for the pursuers, and Mr. Asher, Q.C., and Mr. Watt, instructed by Messrs. Clark and Macdonald, S.S.C., represented the defender.

In opening the case, Mr. Graham Murray said the legality of the pursuers' letters patent was admitted by the defender; there was, therefore, no contest as to the instruments in question held by the defender being an infringement. The controversy arose through this, that the defender said the instruments were supplied for experimental purposes, while the pursuers maintained that they were not for experimental purposes in the ordinary sense of the words, and even if they were, that would make no difference. Then there was the question as to damage.

Mr. JOHN BREWIS, the first witness, said he was a chartered accountant in Edinburgh, and had examined the defender's books. He found 87 telephones supplied before the date of the action. They were all named with the exception of 37. There were 8 Ader receivers, 13 Ader transmitters, 2 Ader old, 2 Ader No. 3, 5 Berthon transmitters, 2 magneto transmitters, 11 Poiney crown receivers, 6 Gower, 2 Ader domestic, and 36 telephone instruments not defined. All these were supplied, with the exception of two, prior to 9th December, 1890, when the patent expired. In the ledger he found sums stated as having been paid for the instruments. The defender had also paid £195 to a telephone company in Paris between 20th July, 1890, and 30th March, 1891.

Cross-examined by Mr. ASHER, Q.C.—Merry and Cunninghame paid £10 for telephones to the defender. He could not tell from the books what kind of instruments they were. On October 30th, James Wood paid £17 10s. for instruments. There was nothing in the entry to show that the money was received for Ader or Berthon receivers or transmitters. All the instruments entered in the day book as having been sent out were debited against the customers in the ledger.

SAMUEL THOMAS TURTLE, of the firm of Turtle and Appleton, Wandsworth, said that he noticed in the newspapers that the defender had telephones. He wrote to defender on 8th September, 1890, asking about the purchase of some instruments. In reply, witness received a letter stating that as the patents did not run out until December, if the instruments were fixed before that time some risk would be run. Instruments were supplied. Upon second thoughts the firm did not run the risk. The instruments were got in September, but were not fixed until December. The instruments originally sent were taken away early in this year, and new instruments put up.

Cross-examined: His attention was first attracted to the defender's telephones by a news paragraph in the *Daily Chronicle*. The defender, in his letter, said he could supply instruments, but they could not be used without risk until 9th December. Was it not that the defender could not supply the long distance telephone until 9th December, but he could give you one to suit just as well?—No, I cannot say. The instrument sent in September would not work. It was taken away in consequence of complaints by witness, and another put in its place. The account was paid in April.

ADAM FERGUSON CLEMENTS, telegraph superintendent, North British Railway Company, said that in September, 1890, he received a circular from the defender, asking to be allowed to submit a couple of telephone instruments for his inspection. Witness replied that as his instruments were supplied by the Telephone Company, there was no use in sending them. On being pressed witness allowed the defender to send him a couple of Ader instruments on 7th November on trial. On the 23rd December witness received from the defender two telephones (Ader, old), four Ader receivers, and other telephones. Up to the present time witness had not paid for any of these instruments.

In cross-examination, he said he knew there were some telephone improvements in France, and that Mr. Muirhead's name was connected with these. Mr. Muirhead wrote him that a good patent would expire in the end of the year, that railway companies were interesting themselves in improvements, and that he would rely on witness's support in the crusade. Witness was invited to an experiment in Paris. When the French telephone came to him he understood it was for trial. He gave no order except for trial. He spoke of the correspondence referred to by counsel in support of this. There was correspondence as to whether with Mr. Muirhead's instrument they could work a telephonic circuit on the ordinary telegraph wires. At an interview Mr. Muirhead said it would be better to put up a special telephone wire; and witness did not try it on the telegraph wire. He fitted up the first pair of instruments—Ader's—in two rooms of his own office for trial. They did not give very good results, and he put up another pair for experiment. That was between Glasgow and Caldercrooks. They gave much better results. They were not used by the Company at all for any purpose, except trial or experiment. He never understood he had to pay for them. That was never in contemplation.

WILLIAM STEVENSON, assistant telegraph superintendent of the Caledonian Railway, said he was approached by Mr. Muirhead to try his Ader and Berthon instruments. He declined to give any orders until the patent expired. On 8th October last he received a letter from Mr. Muirhead, asking if he had tried the telephones. In reply, he said he had, and had found them satisfactory, but could not say they were better than what he had. On 20th November he met Mr. Muirhead, and got some other instruments from him. He fitted them up in the office of the telegraph superintendent of the railway, but only to try them. They were paid for this year.

In cross-examination witness said it was quite understood that the Bell patent expired on 9th December and in his letter of 10th October he made it clear that he had no intention to infringe the patent. He got some of the instruments about August and tested them, and then returned them. He got more on 20th November, they were handed to him by Mr. Muirhead on the street. He tried them and afterwards told Mr. Muirhead that as the patent had expired they could keep them and to send his account, that was a magnetic Ader transmitter.

At this stage Mr. MURRAY stated in reply to the Judge that the pursuers wanted damages for the experimental use of the instruments.

Lord KYLLACHY: How much do you think you are likely to get.

Mr. MURRAY: That is a different matter.

Lord KYLLACHY: Of course there may be a question of expenses which may depend upon the question of damages.

Mr. ASHER: Of course it is all a question of costs. I have told my friend frankly that it is a question of where the delicate matter of experiment passes the line. I have no desire to infringe his patent and he may have his interdict, and I am willing to pay his costs.

Mr. MURRAY: Not taxed on the ordinary scale.

Lord KYLLACHY: I have a great objection to occupying the time of the Court as to a question of costs taxed in one way and another.

Mr. MURRAY: My clients think considerable damage has been done.

Lord KYLLACHY: Of course if you can make out substantial damage I shall know how to deal with the matter of costs.

Mr. ASHER: I am quite sure of this that my friend cannot trace one shilling into my client's pocket.

Mr. MURRAY: I may not be able to prove much damage in one sense; but I will say there is some damage in another. The defender has ground-baited the trade in the whole of the Kingdom. He has gone to railway companies giving them instruments and saying "then if you think these will suit you the moment the patent expires you will give us a chance." He has no business to do that.

Lord KYLLACHY: How does that affect the patent. There may be something to say as to the instruments for which the patent has not expired, but keep in view if you have suffered only nominal damages and are offered your interdict with costs, I shall be very much disposed to find you liable in expenses.

ROBERT MAIN, partner of the former firm of Merry and Cunninghame, said he was aware of telephones being supplied to his firm by Mr. Muirhead on 14th July last. Witness gave instructions that Mr. Watson of the United Telephone Company should replace the three telephones Mr. Muirhead had put up, and Mr. Watson took them away. While they were there they were used for the purposes of his firm. They were removed during this year.

In cross-examination, witness said he sanctioned the arrangement for putting up the instrument by Mr. Muirhead. He understood it was a French instrument. It did not work well—a bell did not ring. Some alteration was made on the bells. The original arrangement was for a telephone to cost £5, but the invoice was for £10. Nothing was paid. The United Telephone Company did not charge for removing Muirhead's telephones and putting in others of their own.

J. LAMONT, clerk to Merry and Cunninghame, said he had conversations with Muirhead, chiefly by telephone, in regard to supplying telephones to their office. Ultimately, three were supplied and worked for 4 or 5 months. Eventually they were removed by the manager of the United Telephone Company. After Muirhead's

account had been passed for payment in Glasgow, witness "phoned" from the works to the office that they were out of order and that the account was not to be paid. That was on 9th October.

WILLIAM HOWARD WINTERBOTHAM said he was the English solicitor to the pursuers. He had been engaged in the various litigations in connection with their patents. He had certificates as to both patents. Early last year the defender communicated with the pursuers' Glasgow office as to certain French instruments and suggested their use. A correspondence ensued, in the course of which it transpired that the defender had imported several infringing instruments into this country. Witness wrote him, suggesting that he should return them to France, or proceedings would be taken against him for infringement. The defender was anxious the pursuers should take up the French instruments. There was nothing new about them. After that correspondence the defender did not send the instruments back to France, and pursuers insisted upon them being sent to them. The defender delivered up some instruments which pursuers understood were the whole he had. The pursuers, however, found afterwards that the defender was still advertising the instruments. In his circulars the defender stated that he was selling the same instruments which were in operation between Marseilles and Paris. That, in witness's opinion, included the Edison transmitter, covering the Ader transmitter, the patent for which did not expire until 30th July this year. From witness's practical knowledge of the business, he considered that the sending of circulars to the railway companies was apt to damage the pursuers' business. The profit on a set, a transmitter and a receiver, would be from £6 to £8. Cross-examined.—Witness never had found a customer for any instruments; but as law-agent of the company he attended to contracts and infringements of the patents. He did not know that articles about these instruments appeared in the *Glasgow Herald* and *Scotsman*, and created a flutter amongst people interested in telephones, nor that Colonel Jackson in consequence went to Glasgow to see Mr. Muirhead. The Ader magnetic instruments were not so effective as the Ader carbon transmitter. They were called domestic, and no one would think of using them for long distances. What he considered damaging in the defender's circular was that he was able to supply the same kind of instruments as were in use on the continent.

DANIEL SINCLAIR, manager of the pursuers' company, estimated their loss, on account of the defender's actings, at between £400 or £500.

Cross-examined.—In consequence of the offer to Messrs. Coats, Paisley, by the defender to supply them with the infringed patent, pursuers lowered their rental. The pursuers were lowering the rentals all round. Rentals were lowered to parties who were not approached by the defender. The pursuers considered they would have sold more telephones to the Midland Railway Company if they had not been approached by the defender.

At this point Mr. MURRAY rose and said that at lunch time an offer had been made to him by the defender, and he would not be doing his clients justice if he persisted in continuing the case with the offer before him.

Lord KYLLACHY: You have raised a very nice question as to damage.

Mr. ASHER: It would require a microscope to examine it.

The case was accordingly settled on the footing that interdict was granted as craved, and £5 and costs as between party and party were paid to the pursuers.

PROCEEDINGS OF SOCIETIES.

City and Guilds of London Institute Old Students' Association.

SOME RESEARCHES IN ELECTRO-MAGNETIC INDUCTION.*

By E. B. VIGNOLES.

The subject of electro-magnetic induction is one whose ramifications extend into almost every commercial application of electricity. I need, therefore, little excuse for bringing before you to-night a short account of an investigation into induction phenomena which, even if it traverses somewhat well-trodden ground, presents some novel features of method and application which may perhaps repay your attention.

Before proceeding to describe to you the method used by Mr. Evershed and myself in these investigations, I may perhaps briefly state the circumstances which led to our undertaking the research. When we started our experiments some two years ago, the subject of transformers was being much discussed; and as we, in common with most other people, were rather hazy in our ideas concerning the actions of this convenient but perplexing machine, we determined to investigate these actions from the beginning by determining, *de novo*, the magnetic properties of closed rings of various materials. The method of drawing the actions of a transformer as described in Mr. Evershed's Papers was then in process of conception, and he saw that these curves were the one thing needful. We knew, of course, that Ewing and Hopkinson had already published similar curves, but their Papers are somewhat inaccessible, and their methods seemed to us open to some objections, objections of which I will treat further on.

But before I proceed to further describe the methods used, it may be as well, since the nomenclature of magnetic phenomena is in a somewhat amorphous condition, to describe the sense in which various terms will be used in this Paper.

The first thing that we have strongly set our faces against is the use of the term "induction" in the sense of "induction density." It is as if we had no term for current, and used current in the sense of current density. It simplifies one's nomenclature to call $B \times$ area "the induction," just as in the case of current; and to call B the "induction density," and I shall take the liberty of doing so in this Paper.

I shall not allude to "I," for the good reason that I can form no conception of what it means physically. I fancy it is something to do with the induction density that would have been present in an electric circuit of the iron which is there wasn't there! It seems useless to make such artificial distinctions, and I follow Dr. Hopkinson's distinguished example in treating of nothing but B, H, and μ.

The remaining point as regards nomenclature is the abuse of the term "lines of force." As expressing the direction in which the induction acts at various points, they have an obvious and valuable use; but these lines do not increase or diminish as the induction becomes greater or less. Whether you have 10^{-10} or 10^{+10} units of induction, the lines of force remain precisely the same. They should be symbols of *direction* and not of *quantity*. The use of the term "lines of force" for units of induction, not only leads to false mental pictures, but it is clumsy. We were, therefore, compelled to invent a new unit for induction, as no one else had done so. This unit was born some two years ago, and was christened the "Thom," after our leading electrician. It serves its purpose: you can speak of a "Thom" without committing yourself to anything, or thinking of anything in particular.

The Paris Congress has adopted a unit of induction density called the Gauss. It is really an unnecessary unit, as "Thom's per sq. c.m." is all that is required; but it is convenient, and we have always used it. It simplifies the numbers on the curves of B and H to be called 1,000 gausses, a "kilo-gauss" in the usual metric manner; and I have done this in my tables and curves, where H is in dynes, and B in "kilo-gausses."

Having thus explained my use of terms, let us return to the consideration of the action of iron in transformers.

The importance of imitating as closely as possible the action of the magnetising current in a transformer strongly impressed us. We saw that it was necessary, when investigating any induction cycle, to carry the iron through that cycle before every observation, and always to start from one extremity of the cycle.

It may be said that the ordinary method of procedure, by reducing the current from the negative maximum by jumps to o, increasing to the positive maximum in the same way, and then reversing the process, noting at each jump the throw of the ballistic galvanometer, is equally good; but this is not so, for in a transformer you are not stopping anywhere on the force-induction curve, except at the positive and negative maxima. It might happen that the iron behaved differently in the two cases; and we know from Ewing that the induction has a tendency to creep up under the prolonged action of a magnetising force.

Magnetometer methods were out of the question, for iron rods do not behave like closed rings, unless, according to Ewing, their length is about 400 times their diameter. As we wished to experiment on masses of iron, and not on wires, which might, and, in fact, do, behave very differently, the minimum diameter we could have used would have been half an inch. This makes our rod 18 feet long, which is somewhat alarming.

Hopkinson's method is a very handy and convenient one, but the fact that it introduces other material than the one under test, and that at least two, and generally three, joints are necessary parts of the magnetic circuit, is a great disadvantage. It may be that a very small portion of the magnetising force is spent on the "return" block, but still there is always something; and that something is rendered somewhat indefinite by the hysteresis of the block. This amount may, however, be indefinitely reduced by making the block big enough, but it is not so with the joints. It will always take an appreciable percentage of the magnetising force to push the induction through these joints, and this percentage will vary in every sample of iron tested, owing to minute differences in the tightness of the joint. It will be noted that since the bar has to be pulled out suddenly, the joint with the block can never be made really very tight. A modification of this method using very tight joints, and winding with two primaries (as in our method) to avoid having to pull out the test bar, might have its advantages; for it would no longer be necessary to wind each sample of iron, which is, of course, essential in the ring method, and it saves one joint; but, turning the bars would entail nearly as much work as winding a ring, and work of a more expensive class, for any boy can wind one of our rings properly, but accurate turning would require more skilled labour. Thin laminæ of iron, as used in transformers and armatures, cannot be tested by this method, which practically puts it out of the question.

The most important experiments performed by means of rings, according to Kirchhoff's method, are those of Bosanquet. He, however, did not, as far as I know, take hysteresis curves, but confined himself to average curves, obtained by means of the reversal method. For testing iron where the amount of coercive force is not required this method is excellent, and many of our curves have been thus obtained.

To obtain the hysteresis curves, and to ensure the conditions being the same as in a transformer—that is to say that the magnetising force must always be carried from one extremity of the cycle to the point under observation at one fell swoop—we adopted the following method of winding.

The rings are generally about 13 cm. in diameter, and one or two square cm. in area; they are wound continuously all round with two

* A Paper read May 13th, 1891.

primary coils, P_1 and P_2, and a secondary, S, is wound on, generally over the primaries for convenience, to produce the galvanometer deflection. One primary has preferably twice the turns of the other; in any case the currents must be so arranged that at the maximum the ampère turns on P_2 are twice those on P_1.

The arrangement of the circuits is shown in fig. 1, where the coils

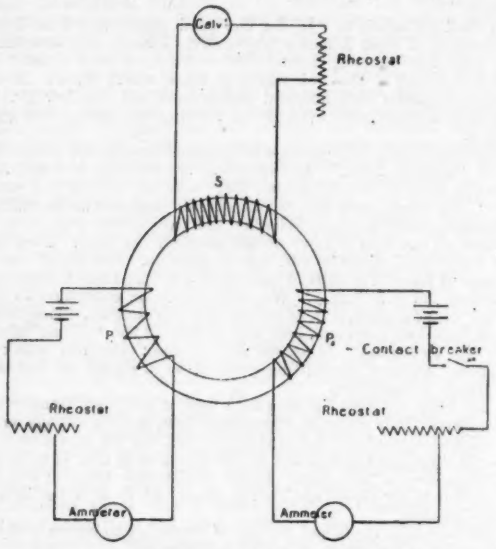
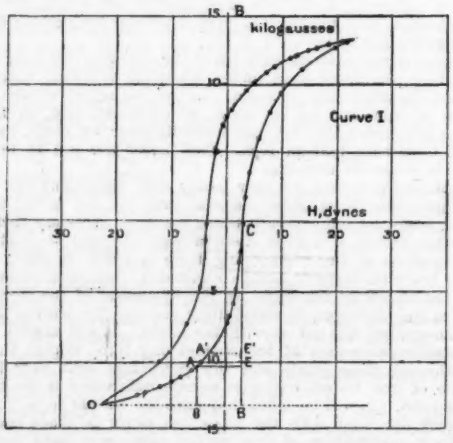


Fig. 1.—ARRANGEMENT OF APPARATUS FOR TESTING.

are drawn separately for the sake of clearness; they really are wound over one another.

P_1 has say n turns, P_2 has $2n$ turns.

A current of some definite value, so arranged that the total magnetising force is of the dimensions required to keep the iron at the end of the cycle to be investigated, is kept up constantly in P_1; thus holding the iron at the negative maximum (O, Curve 1), when P_2 is not in action.



When a current of the same value, but in the opposite direction, is flowing in P_2 the iron is carried to its positive maximum, since P_2 has twice as many turns as P_1.

The mode of obtaining the curve is now obvious. Let Curve 1 represent the cycle under investigation. The "fiducial current" in P_1 is, say, 10 ampères; this current remains on all the time the cycle is being obtained, and is kept always accurately at the same value.

10 ampères are then put through P_2 in the reverse direction, and then broken; carrying the iron to the positive maximum, and returning to O, the fiducial point.

The observation is then made by making a small current in P_2 (thus reducing the net ampère turns), and noting the deflection of the ballistic galvanometer. The ordinate A B is thus obtained.

The iron must then be again carried to the positive maximum, and back to O, by making and breaking 10 ampères in P_2.

The next point is obtained similarly, by making a somewhat larger current in P_2; this gives the ordinate C D.

Note that any observation can be repeated at once, which is often necessary, and which is impossible by the ordinary method.

Similarly the whole rising curve is obtained, the iron being put through its cycle between each observation, to remind it that it is a transformer.

The falling curve is of course similar, and may be obtained by eversing the currents in both coils.

Now, if this curve is obtained in the ordinary manner by successive jumps, first from O to A, then from A to C, and so on, the iron has time between successive observations to creep up along the curve from A to A' say, and the ordinate E' C is obtained at the next jump instead of E C. The sum of the deflections is then not great enough. Also the quantities passing through the galvanometer are not as great as they are in our method, and consequently the chances of error are greater.

Curve 1 is a curve obtained by our method, which shows its extreme value in the steep parts of the curve. Table 1 gives the actual values of the B and H (the induction density in kilo-gausses, and the magnetising force per centimetre of length in dynes), obtained by observation, and it will be noticed that even in the steepest parts the curve can be traced with absolute certainty, every observation being exactly on the curve.

TABLE I.—WROUGHT IRON, UNANNEALED.

Rising.			Falling.		
No.	H	B	No.	H	B
1	− 15·75	− 12·5	23	+ 21·5	12·9
2	− 14·5	− 12·35	24	18·4	12·7
3	− 11·4	− 11·8	25	16·95	12·6
4	− 9·3	− 11·4	26	14·9	12·3
5	− 7·9	− 11·0	27	13·1	12·1
6	− 5·8	− 10·4	28	12·8	12·0
7	− 4·4	− 9·8	29	11·4	11·8
8	+ 0·35	− 7·2	30	8·75	11·2
9	+ 1·0	− 6·6	31	7·35	10·8
10	+ 1·4	− 5·9	32	5·2	10·0
11	+ 1·9	− 5·0	33	3·7	9·5
12	+ 2·5	− 3·4	34	0·7	7·9
13	+ 2·6	− 2·9	35	0·2	7·6
14	+ 3·3	− 0·25	36	− 0·7	7·0
15	+ 4·0	+ 1·8	37	− 3·7	− 0·25
16	+ 4·7	+ 3·4	38	− 4·0	− 1·4
17	+ 6·3	+ 5·8	39	− 5·1	− 4·8
18	+ 8·2	+ 7·9	40	− 7·2	− 7·2
19	+ 10·3	+ 9·1	41	− 10·3	− 9·4
20	+ 14·0	+ 10·9	42	− 11·5	− 9·8
21	+ 19·3	+ 12·4			
22	+ 22·0	+ 12·9			

It has been asserted that the induction is unstable at the steep part of the curve; this is not so, as far as masses of iron are concerned, for we have never had any difficulty in stopping at any part of the curve and reproducing an observation. In connection with this subject of instability, I may mention another point which is noticeable. Prof. Ewing found that the residual induction in his soft iron wires was very unstable; so much so, that a man walking in an adjoining passage caused enough vibration to shake all residual induction out. Mindful of this, we carefully tested our early rings for this effect; while Mr. Evershed held the galvanometer switch over, I gently stroked the ring—nothing happened; I tapped it lightly—still nothing. I ended by smiting it with a hammer, under which severe treatment it yielded up 2 per cent. of its residual induction! We concluded, therefore, that it required considerable *molar* vibration to affect masses of iron. It is not so with *molecular* vibration. A very small force applied by means of an electric current, either in the direction of the induction or at right angles to it, shakes out all residual induction.

There are two errors which must be looked for in all methods of measuring induction. First, air induction in the secondary, if it is larger in area than the iron; this becomes of importance when the permeability of iron comes down near that of air, but may be neglected in most cases for small cycles, or calculated and allowed for. Secondly, unsymmetrical winding of the primary or primaries. We found that if a primary be wound half round a ring about 4 inches across, 10 per cent. of the induction leaked across through the air from end to end of the coil; thus H cannot be calculated, owing to the unknown distribution of the magnetising force.

The advantages of the method described being so many, we finally decided to adopt it; and proceeded to manufacture our apparatus.

The ballistic galvanometer, of which details are given in Table II., appears to the naked eye a rough piece of apparatus, but it has performed its work admirably, and has never given us any trouble.

TABLE II.—BALLISTIC GALVANOMETER.

Length of needle = 4·8 cm. Sect. area = ·0726 sq. cm.
Period = 3·8 seconds.
Resistance = 69·6 B.A. ohms at 20°.
Max. angle of deflection = 9°.

My audience must remember that all these experiments were carried out in engineering works, and not in a laboratory; and this fact made us anxious to eliminate every source of error. We had to devise a ready method of standardising the galvanometer every time we used it, as motors and dynamos in the immediate neighbourhood are not conducive to constancy in the earth's field.

We therefore made a solenoid of length 120 cm. and diameter 3 cm. Its length being great compared with its diameter, the field at its centre could be accurately calculated, from the well-known formula

$$H = \frac{4\pi CN}{l}$$

where C is current in ampères, N the number of turns, and l the length.

Assuming that the permeability of the broomstick on which the solenoid was wound to be the same as that of air

$$H = B$$

we thus get the number of Thoms per unit of area at the centre of the coil.

The secondary, wound inside the solenoid in a groove in the broomstick, had 1,000 turns of very fine wire. Its average area was 5·0 sq. cm.

$$H \times \text{area} = \frac{\cdot 4\pi C N}{l} \cdot a$$

gives the induction cutting the secondary.

This broomstick standard thus gives us a means of calibrating our galvanometer as well as standardising it.

The theory of the ballistic galvanometer given in text books says, that the induction is proportional to the throw, under certain conditions, one of which is that if there is damping, corrections must be made by means of a "logarithmic decrement." We did not quite know what a logarithmic decrement was, and so we preferred to try whether our scale was a straight line, by going to the *fons et origo* of all knowledge, experiment. We first proved by experiment that

$$\theta \propto \frac{1}{R}$$

if B × area is kept constant; where θ is the throw, R the resistance of the circuit, and B the induction density. Then we took a curve of B and θ for constant resistance and turns, and this curve cannot be distinguished from a straight line.

If, therefore, all deflections are taken with the same resistance in circuit, the formula is

$$\theta = \frac{a\,n}{R}(B \times \text{area}),$$

where a is a constant depending on the galvanometer.

Owing to the variation of the amount of damping with the resistance of the secondary circuit, this formula is not true (except at the resistance at which the galvanometer was standardised), unless the damping be properly allowed for.

Deflections taken at various resistances can be made comparable with one another, by substituting for them uniformly the value they would have had, if some fixed resistance (infinity for convenience) had been in circuit.

A curve of co-efficients, by which throws at various resistances must be multiplied in order to reduce them to "throw on open circuit," is easily obtained.

A fixed impulse is given by means of an external coil by tapping a key, and the deflection noted for open circuit, and for various resistances. The damping increases as the resistance of the circuit decreases, and the percentage difference from the throw at infinite resistance is thus obtained. This curve is shown in fig. 2. By means

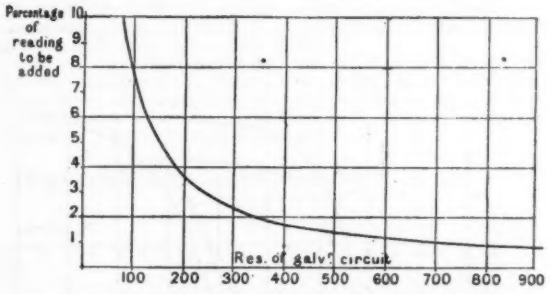


FIG. 2.—BALLISTIC GALVANOMETER DAMPING CURVE.

of it all throws can be reduced to throw on open circuit by multiplying by the required percentage. The curve is a rectangular hyperbola.

We are now prepared to standardise the galvanometer.

Since

$$\theta = \frac{a\,n}{R}(B \times \text{area}),$$

the induction $= B \times \text{area} = \frac{R\,\theta}{a\,n}$;

whence we see the $\frac{1}{a}$ or g, the galvanometer constant is to be obtained. Now,

$$g = \frac{1}{a} = \frac{R\,\theta}{n\,B} \times \text{area},$$

and thus one deflection from a known B in the broomstick gives the required constant.

Any mutual induction coil may be standardised by means of the solenoid, and used as a standard in place of the somewhat clumsy broomstick.

In our "Mutual Inductioner," 1,273 Thoms cut the secondary for 10 ampères in the primary. Everything was now ready, except that all-important item in a research, the elimination of "niggers." I may mention some of these, in case any of you ever have to investigate force induction curves.

It is necessary to break the primary *very* sharply. We had much trouble from double breaks until we made a "jumper," in which a copper wire filed to a point was pulled from a mercury cup by elastic. This arrangement is perfectly satisfactory.

Bad contacts in the secondary circuit are a fruitful source of error when working with low resistances. We have made a rocking mercury cup switch, which when put over to the left, throws the ballistic galvanometer into circuit, and when over to the right short circuits the galvanometer, and puts the remainder of the circuit on to the bridge, so that its resistance can be taken if necessary before or after each deflection, since the resistance alters by heating. To avoid these errors, wind many turns of secondary, so as to have *large* resistances in circuit; in this case the heating of a secondary of a few ohms does not matter.

A great many errors may be due to the currents in the primary circuit affecting the ballistic galvanometer directly. We leave our leads long, and can then raise, lower, or coil them up, till currents in them do not affect the galvanometer. This point is most important, especially with large primary currents. These "niggers" having been discovered and eliminated, we were in a position to begin our research.

I have entered into a lengthy and detailed description of the method employed, as it is novel, and presents very great advantages. I have thought it better to be too precise rather than not precise enough; for it is generally my experience that it is exactly the information you wish most to have which is omitted. For instance, in Dr. Hopkinson's classic paper, the actual observations from which the curves are taken are not given, and from the scale of these the lower parts are difficult to trace.

In the following tables I give you the actual figures of some typical results:—

TABLE II.—MAGNET BAR IRON.

Average length = 35 cm. Sectional area = ·877 sq. cm.

	Rising.		Falling.	
No.	H	B	H	B
1	—39·5	—15·55	48·3	15·8
2	—29·6	—15·1	38·5	15·4
3	—19·75	—14·5	28·6	15·05
4	— 9·9	—13·4	19·75	14·4
5	— 0·4	— 7·75	9·9	13·2
6	+ 1·0	— 3·7	— 0·6	6·9
7	+ 3·0	+ 4·4	— 2·0	— 2·0
8	+ 9·9	+ 11·8	— 4·9	— 8·9
9	+ 20·7	+ 14·0	— 9·9	—12·15
10	+ 29·6	+ 15·0	—29·6	—14·95
11	+ 39·5	+ 15·6	—39·5	15·55
12	+ 48·3	+ 15·8		

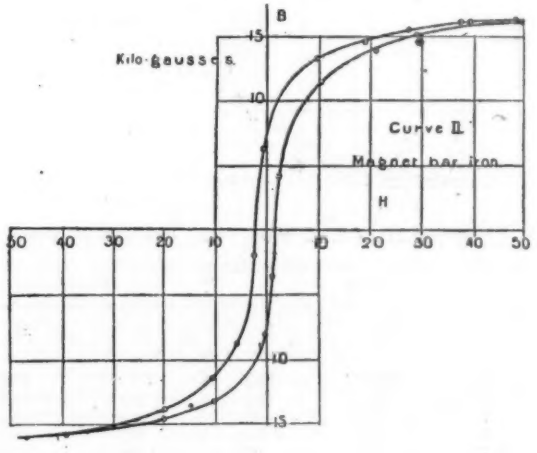


TABLE IIA.—SAME RING, SMALL CYCLE.

	Rising.		Falling.	
No.	H	B	H	B
1	—2·0	—7·7	5·0	8·5
2	+ 0·79	—4·6	2·8	8·0
3	1·6	—1·6	1·0	6·8
4	1·8	—1·05	—0·7	4·7
5	2·5	+ 2·7	—1·2	2·7
6	2·8	4·0	—1·6	—0·1
7	3·7	6·5	—2·0	—3·0
8	5·0	8·2	—3·5	—7·0

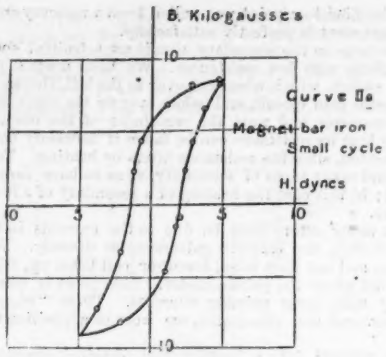


TABLE III.—CHARCOAL IRON, WITH SCALE ON.

	Rising.		Falling.	
No.	H	B	H	B
1	—48·3	—15·2	55·1	15·2
2	—40·2	—15·0	12·7	13·2
3	—21·8	—14·3	4·6	11·6
4	— 4·6	—12·5	0	9·0
5	— 0·6	—10·9	— 1·9	— 0·4
6	± 0	— 9·2	— 2·9	— 5·3
7	+ 2·9	— 0·2	— 6·9	—10·6
8	6·9	+ 9·6	—10·4	—11·9
9	11·5	11·9	—30·1	—14·8
10	47·1	14·8		

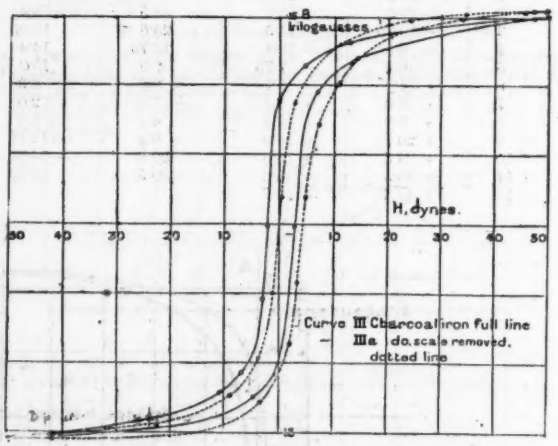


TABLE IIIA.—SAME RING, SCALE REMOVED BY ACID.

	Rising.		Falling.	
No.	H	B	H	B
1	—32·4	—15·2	53·3	16·2
2	— 2·5	—12·5	23·4	14·7
3	+ 2·0	— 8·0	9·0	12·6
4	+ 3·2	— 3·8	3·2	8·7
5	+ 4·4	+ 1·75	0·4	1·85
6	6·4	6·8	± 0·	+ 0·6
7	8·8	9·9	— 1·2	— 5·1
8	12·4	12·1	— 3·7	— 9·8
9	18·2	13·5	— 8·6	—12·6
10	31·9	14·8	—22·2	—14·5
11	56·0	15·8	—39·9	—15·2

The apparent increase in permeability is accounted for exactly by supposing the scale to have no permeability. Its removal decreases the area, and therefore increases the apparent B.

Note in the second curve, No. IIIa., the displacement of the curve with regard to the zero of magnetising force. We have not been able hitherto to account for this phenomenon satisfactorily. We have found it in several curves, the displacement being in some cases very large. It is perhaps due to a bias in the iron produced by a previous very high magnetising force in the direction of displacement.

TABLE IIIB.—THE SAME MATERIAL, ANOTHER RING. AVERAGE FORCE INDUCTION CURVE, OBTAINED BY REVERSALS, FOR HIGH MAGNETISING FORCES.

No.	H	B	No.	H	B
1	10·0	12·0	6	96·0	15·9
2	20·0	13·4	7	110·0	16·0
3	39·8	14·4	8	132·0	16·4
4	61·2	15·1	9	158·0	16·6
5	84·0	15·6	10	179·0	16·9

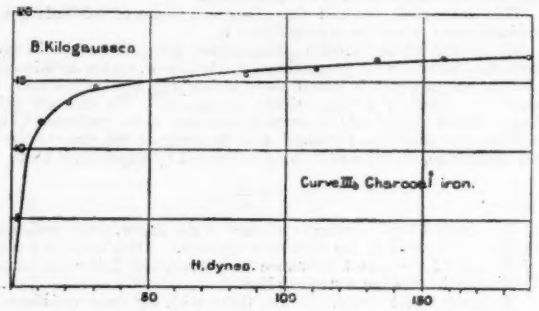


TABLE IIIC.—CHARCOAL IRON. SMALLER CYCLE.

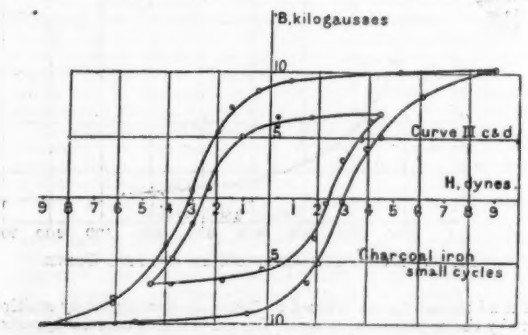
No.	H	B
1	—3·81	—6·7
2	—1·77	—6·3
3	—0·41	—5·86
4	+ 0·97	—5·0
5	1·87	—3·22
6	2·36	—0·5
7	3·04	+ 2·4
8	3·72	4·6
9	4·42	6·3
10	4·6	6·65

Hysteresis loss: 4,650 ergs per cubic centimetre per cycle.

TABLE IIID.—SAME RING.

No.	H	B
1	— 9·0	—10·3
2	— 5·16	—10·0
3	— 0·8	— 9·1
4	+ 0·5	— 8·1
5	+ 1·4	— 7·1
6	+ 2·0	— 5·2
7	+ 3·0	— 0·2
8	+ 4·0	+ 3·9
9	+ 4·45	+ 5·0
10	+ 6·1	+ 8·2
11	+ 8·4	+ 10·1
12	+ 9·0	+ 10·3

Hysteresis loss: 9,990 ergs per cubic centimetre per cycle.



This curve may be folded back to form the falling curve, as we have found that taking the falling curve by "breaking" methods gives too small an area, owing to causes which hardly come within the scope of this paper.

I have given the falling curves obtained by carrying the iron through the cycle to the required point on the downward curve and then breaking F_2; but since taking them we have discovered the reason of their "humpbacked" appearance. In nearly every case, the falling curve comes down more perpendicularly than the rising curve, and for getting the hysteresis area more accurately it is best to fold over the rising curve. The iron cannot know which way round it is.

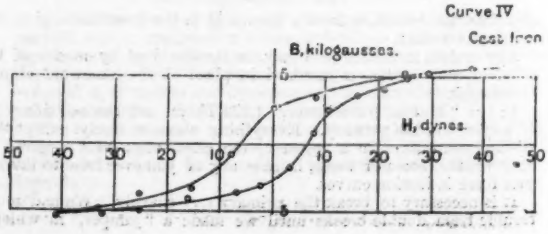


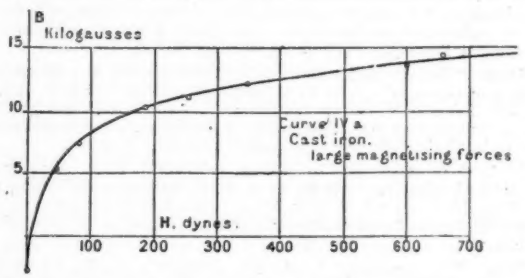
TABLE IV.—CAST IRON.

Average length = 32·6 cm. Area = 0·88 cm.

	Rising.		Falling.	
No.	H	B	H	B
1	—32·3	—5·4	43·7	5·7
2	—24·5	—5·1	33·2	5·3
3	—15·7	—4·6	24·9	4·75
4	— 6·6	—3·97	16·6	4·3
5	— 1·7	—3·36	8·3	3·66
6	+ 3·3	—2·2	± 0·	2·55
7	7·5	+ 0·5	— 8·3	—1·0
8	10·4	+ 2·0	—16·6	—3·4
9	15·7	3·4	—24·9	—4·5
10	20·7	4·1	—33·2	—5·16
11	28·2	5·0		
12	37·3	5·44		
13	43·5	5·7		

TABLE IVa.—SAME RING, RISING CURVE FOR HIGH MAGNETISING FORCES.

No.	H	B	No.	H	B
1	3·0	— 2·9	5	266	11·5
2	47	+ 6·4	6	353	12·3
3	91	8·4	7	596	13·9
4	178	10·3	8	662	14·6



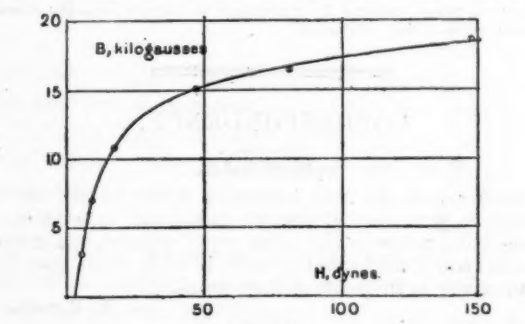
These curves only give an idea of the behaviour of cast iron. This material is very variable in its magnetic properties. Other specimens have given higher permeability.

I will now give you the result of a test of a specimen of mild cast steel, from Langley Mills, Nottingham. Note that for large magnetising forces its permeability is nearly as great as wrought iron. The observations are by reversal method, as the hysteresis area was not required. The steel was not annealed.

TABLE V.—MILD CAST STEEL.

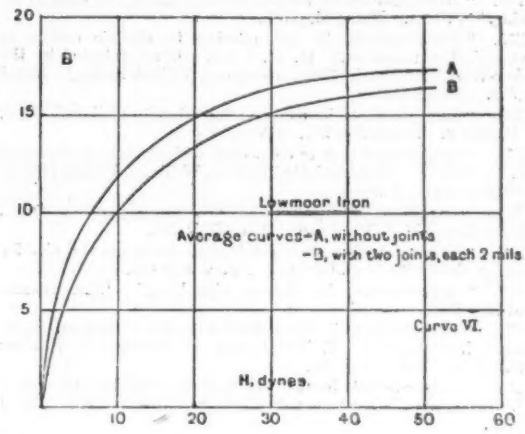
Av. length = 43·3 cm.
Area = 1·156 sq. cm.

No.	H	B	No.	H	B
1	5·15	3·1	5	82·5	16·6
2	8·75	7·0	6	148	18·2
3	17·3	11·2	7	240	19·0
4	48·8	15·2	8	288	19·9

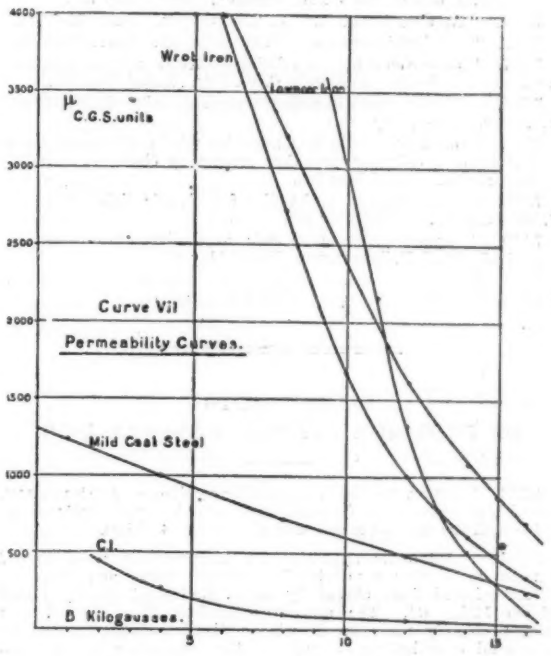


CURVE V.

Curve VI. shows the result of introducing air gaps amounting to $\frac{4}{1000}$ inch in a Lowmoor iron ring of 1·13 sq. cm. area, and 31·4 cm. long. It was obtained (the A curve) from a continuous ring, which was then sawn through, and the gap refilled by a piece of the same material, grain in the same direction. Thus treated the curve fell to B, a difference even at large induction densities of 5 per cent or so.



Curve VII. exhibits in a comprehensive manner the results of the tests, taking average permeability, and as far as dynamos are concerned, these curves give all the information necessary.



The above curves embody practically every material which we have tested.

I could say much as to interesting side issues which have cropped up in the course of the research, but I have thought it best to keep strictly within the lines laid down at the commencement—a description of our method and the results obtained by it.

Even as I write this, I see the bearing of much of our work upon such vexed questions as the supposed "Mordey effect" (the decrease of hysteresis at full load), viscous hysteresis, and so on. But I should open so vast a subject and one on which so little is known, if I were to be led off to these subjects, that I think these questions must be reserved, I hope for a future paper.

At the same time I cannot help stating here that some of the points brought out by these researches seem to us to have vital bearing on the subject of transformers, and also to a certain though less extent on that of dynamo armatures; and these points it will now be our business to further investigate.

NEW PATENTS—1891.

7,667. "Improvements in dynamo-electric machines and electric motors." H. L. CALLENDAR. Dated May 4th.

7,688. "A spiral filament for incandescent electric lamps." A. SAUNDERS. Dated May 4th.

7,697. "Improvements in electrical accumulators or storage batteries." C. P. ELIESON. Dated May 4th.

7,702. "Improvements in or relating to the construction of electric lampholders, and other electric appliances." A. HOSTER. Dated May 4th.

7,728. "Improvements in lamp-posts or columns for electric arc lighting." J. LEA. Dated May 5th.

7,755. "Improvements in and relating to electric motors or dynamo-electric machines." H. H. LAKE. (Communicated by the Crocker-Wheeler Electric Motor Company, United States.) Dated May 5th. (*Complete.*)

7,762. "Improvements in reciprocating electric engines." C. J. VAN DEPOELE. Dated May 5th. (*Complete.*)

7,778. "Improvements in or connected with electric conductors." W. P. THOMPSON. (Communicated by J. B. Williams, United States.) Dated May 5th. (*Complete.*)

7,782. "Improvements in electrical induction apparatus." C. J. WALLASTON and F. J. MUDFORD. Dated May 5th.

7,822. "Thermo-electric stove for heating purposes, and also for producing electricity." P. GIRAUD. Dated May 6th.

7,827. "Improvements in railway signalling." I. A. TIMMIS. Dated May 6th.

7,857. "Improvements in the construction of rheostats or similar electrical instruments." F. BRYAN and WOODHOUSE & RAWSON UNITED, LTD. Dated May 7th.

7,858. "Improvements in switches used for electrical purposes." C. S. SHELL and WOODHOUSE & RAWSON UNITED, LTD. Dated May 7th.

7,863. "An improved method of and means for cultivating land by the employment of an electric current." R. R. HUTCHINSON, W. B. HUTCHINSON and J. HUTCHINSON. Dated May 7th.

7,878. "Improvements in appliances for preventing ignition of gases in connection with dynamos, motors, or other electrical apparatus." F. J. ROWAN and W. MCWHIRTER. Dated May 7th.

7,911. "An electric switch." G. S. GRIMSTON. Dated May 7th.

7,912. "An electric capstan." G. S. GRIMSTON. Dated May 7th.

7,937. "Improvements in or relating to electric resistance devices for measuring electric currents." C. W. COX. Dated May 8th.

7,954. "Improvements in and relating to electric call apparatus." G. POORE. Dated May 8th.

7960. "Improvements in apparatus for use in the manufacture of metal tubes, cylinders, or other articles by electro-deposition." R. D. SANDERS. Dated May 8th.

7,976. "Improvements in handles for electric light switches." G. BINSWANGER. Dated May 9th.

7,979. "Improvements in electric accumulators or secondary batteries." G. E. B. PRITCHETT. Dated May 9th.

8,031. "Improvements in apparatus for heating and welding by the electric arc." H. HOWARD. Dated May 9th.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1890.

3,732. "Improvements in electro-locomotives." J. HOPKINSON. Dated March 8th. 6d. Consists in using a four-pole dynamo machine with the magnets arranged horizontally. 4 claims.

3,841. "Automatic apparatus for compensating variations of current in electric conductors." SIEMENS BROS. and Co., LD. (Communicated from abroad by A. M. Taylor, of India.) Dated March 11th. 6d. The apparatus consists of a ring of soft iron, preferably made up of wire or laminæ having wound on it several convolutions of each of the conductors to be compensated, the convolutions belonging to the several conductors, occupying different parts of the circumference of the ring. Those of the conductors which have to convey electricity farthest have the fewest convolutions, and the others have the number of their convolutions properly proportioned according to their conditions, those which have the least resistance in their course having the greatest number of convolutions. 1 claim.

3,842. "A circuit-breaker for secondary currents from electrical transformers." SIEMENS BROS. and Co. (Communicated from abroad by A. M. Taylor, of India.) Dated March 11th. 6d. One of the leads from the secondary coil has to pass on its way through two pairs of contacts, one of each pair being the contact of two carbons, and the other of each pair being a wire dipping in a cup of mercury. The two wires and the two upper carbons are all fixed to an elastic metal bar, which is attached to the core of a solenoid coil, this core being itself suspended by an adjustable spring within the solenoid coil, which consists of convolutions of one of the main high tension leads. While the high tension current is maintained, the core is drawn down in opposition to the spring, bringing the upper carbons in contact with the lower carbons and then immersing the wires in the mercury, thus closing the circuit of the secondary coil of the transformer with the consumer's lead. When there is no current in the high tension lead, the core, being no longer drawn down, is raised by the spring, first drawing the wires out of the mercury while there is still contact of the carbons, and finally separating the carbons, so that the secondary of the transformer is no longer in circuit with the consumer's lead. By making the carbon contacts the last to be separated, sparking at the surface of the mercury is avoided. 1 claim.

3,913. "Improvements in alternate current transformers." G. KAPP, W. C. JOHNSON, and S. E. PHILLIPS. Dated March 12th. 8d. Claims:—1. In a transformer with closed magnetic circuit; the combination of a straight core composed of thin soft iron strip, with one or two ring-shaped yokes, also composed of thin soft iron strip, the core being laid across the yoke rings, so that the surfaces of the core strip and yoke strip cross at right angles or nearly at right angles. 2. In a transformer with closed magnetic circuit the use of yokes made by winding a continuous strip of soft iron to a ring shape, in combination with a straight core laid diametrically across the yoke rings and insulated copper wire coils surrounding the middle portion of the core, and surrounded by the corresponding portion of the yoke rings. 3. The construction of transformer as described with reference to the drawings.

13,319. "Improvements in electric bells and motors." J. TOWNLEY. Dated August 25th. 8d. Relates to a contrivance attached to the ordinary form of electric bells or motors in which the magnetism is retained in the armature until it reaches a certain point also for completing a circuit and breaking the same automatically by means of a wheel having projections on its periphery. 3 claims.

15,547. "Improvements in locked switches for electric current circuits." J. A. ALIFFE and F. TEAGUE. Dated October 1st. 8d. Relates to improvements upon the invention covered by letters patent No. 6,267, dated 29th April, 1887, and No. 18,825, dated 24th December, 1888. The object of the present invention is to avoid or remove certain difficulties found in the practical working of the above specified invention, and to make the same more complete and efficient. 7 claims.

16,064. "Improvements in electrical batteries." J. K. PUMPELLY and T. BUTTERWORTH. Dated October 10th. 6d. Loose cellulose is packed in the cell and prevents the gravitation and consequent concentration of the acid in the electrolyte in the bottom of the cells, thus rendering the upper plates, arranged horizontally, just as efficient as the lower ones. 6 claims.

16,346. "Improvements in apparatus for use in the distribution of electricity by storage batteries." S. C. C. CURRIE. Dated October 14th. 8d. The object of the invention is to provide a suitable and reliable means, whereby the potential of a system of storage batteries may be maintained constant when the output of current is variable according to the requirement of the working circuit. 6 claims.

16,653. "Improvements in apparatus for measuring the strength of electric currents." S. C. C. CURRIE. Dated October 20th. 6d. Consists of an electric current indicator having the magnetisable parts thereof composed of iron filings, chips, or shavings mixed or combined with an insulating adhesive substance or material. 6 claims.

17,181. "Improvements in electric switches." H. J. ALLISON. (A communication from abroad by J. A. K. McGregor, H. Wallach, and S. J. Wallach, all of New York.) Dated October 28th. 8d. Relates to devices for preventing the accidental closing of a switch when in use.

17,728. "Improvements in electric railways." M. W. DEWEY. Dated November 4th. 8d. Consists in the combination in an electric railway of a source of irregular or alternating currents, a line working conductor extending therefrom, a series of coils distributed apart along the way, and connected with the conductor in series, a vehicle, an electric motor to propel said vehicle, electric connections between said motor and working conductor, and means carried by the vehicle to cause the generation of counter-electromotive force in one or more of the said coils near the vehicle. Consists further and more specifically in the combination in an electric railway of a source of irregular or alternating currents, a line working conductor extending therefrom, a slotted conduit containing the conductor, a series of coils distributed apart along the way and connected with the conductor in series, an iron core for each of said coils, and having exposed poles extending along the way, a vehicle, an electric motor to propel said vehicle, electric connections between said motor and working conductor, an iron body carried by the vehicle and arranged to make contact with said poles to maintain one or more closed magnetic circuits at or near the vehicle during its movement, to cause the generation of counter-electromotive force in one or more of the said coils at or near the vehicle and between the connections. 15 claims.

18,412. "Improvements in electric batteries and lighters for cigars and other purposes." D. ROBERTSON. Dated November 15th. 6d. Relates to an arrangement in which the zinc of the battery is immersed when required by depressing a plunger key, the vessel having a domed top. 3 claims.

CORRESPONDENCE.

Deptford Mains.

Having read the most interesting article on the above subject in your issue of the 8th inst., I fail to notice anything which points to the joints being soldered, and would like to know if mechanical pressure is solely relied upon for conductivity in the joints of these mains.

C. N. Russell.

May 26th, 1891.

[We believe that mechanical pressure only is relied upon; we are not aware that the joints are soldered.—EDS. ELEC. REV.]